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Forthcoming Events.

APRIL 3.

Birmingham Association of Mechanical Engineers.—"The Metallography of Steel," by A. Hudson.

British Foundrymen's Association (Lancashire Branch).—Annual Meeting and Paper.

NOTES AND COMMENTS.

Soldering Aluminium.

In an article on "Aluminium in the Foundry," which we publish on another page, the author comments on the absence of a good soldering medium for aluminium. A solution to the problem of how to solder aluminium has been troubling experts for years, and many different kinds of solder have been brought out, but it was found impossible to achieve a satisfactory result with the intermediate substances used for other metals. The consequence was that the idea became prevalent that no kind of liquid could be used for soldering aluminium, and the only thing to do was to use one of the many different alloys made. However, the lack of an effective flux caused the formation of oxide which always prevented a proper joint being made. Prompted by the conviction that without an intermediate it was impossible to make a good soldered joint, Mr. Otto Nicolai, of Boppard-on-Rhine, managed to make a good flux after much experimental work, but the problem was not really solved without having a solder with the same fusing point as the flux. The inventor's next step was, therefore, to find a suitable solder. He ultimately succeeded in getting over this difficulty as well, so that an effective solder can now be had. An important feature is stated to be that one need only scrape the aluminium to make it clean before soldering, and wipe the joints with the Nicolai flux. Solder mixed with the flux is then put on to the joint and will run into the crevices by itself; it will cover surfaces of several square centimeters in area and the joint obtained in the end is claimed to be inseparable. We understand that Nicolai solder and flux are being used at the Imperial dockyard at Kiel and at the Royal gunpowder factory at Spandau.

Welding Cast Iron.

Another problem which it is stated has now been solved is that of welding cast iron. Messrs. A. Beltzer and C. Delcampe claim to have accomplished this by means of a flux, consisting of 65 per cent. potassium chloride, 15 per cent. lithium chloride, and 20 per cent. potassium fluoride. They pre-heat the surfaces to be welded, sprinkle them with the flux powder, and then heat the surfaces to substantially the melting point. It is preferred during this heating operation to add cast iron to the joint, and for this purpose a rod or pencil of cast iron is dipped in the flux and presented to the heating flame, where it is melted and flows on to the joint much in the same manner that solder is applied to a joint in soldering pieces of tin together, except, of course, that being cast iron, the cooling process is so much faster that each portion of the joint must be finished as the heat is advanced along it. The addition of the flux to the cast-iron rod, which is melted on a joint, is for the purpose of refining the cast iron as it is applied to the joint, so that it will form a union with the pieces of cast iron to be welded,

and also to bring some flux into the molten metal of the pieces to be welded. Blow-holes may be filled by the addition of cast iron in the above-described manner, so also errors in workmanship may be cured by adding cast iron to surfaces where too much has been removed; or, again, a protuberance may be formed by adding cast iron at any particular place where it is desired. It is claimed that when such cast iron is added to an original casting or piece the added portion and its joint with the original iron are stronger than the original casting.

Pig-Iron and Analysis.

To return to this topic, which has received somewhat vigorous handling both in this country and in America by foundry associations and other authorities, the discussion at the meeting of Birmingham foundrymen, which we report on another page, shows that the matter is not being allowed to rest. There appears to be a strong feeling that the "blast-furnaceman," as the pig-iron maker is familiarly termed, is quite unwilling to have anything to do with selling his iron on a basis of chemical analysis, and that some considerable united effort on the part of the foundryman will be needed before he can be "brought into line." We will not go so far as to say that we know of any pig-iron maker who would welcome the innovation desired by the foundryman, but at least it cannot be denied that the use of chemical analysis is coming more into favour as a means of assisting the maker in producing his iron to the best advantage. At present we cannot see that there is much incentive to apply the same means to producing irons of more or less definite chemical composition. A certain section of the buying world may strongly urge that basis, but the average user is quite content to accept an approximate grading of the iron regardless of the importance of its constituents. When the demand for irons, different consignments of which do not materially vary in their chemical composition, becomes general, the blast-furnaceman will give greater attention to the production of such uniform material. At present he is not called upon to maintain any standard, except by a few purchasers, and the requirements of these being generally of some size, can be separately dealt with. Once the demand for a regular product becomes general, the producer will, perforce, have recourse to chemical analysis, and from that stage to the selling by analysis will not be such a formidable journey.

The question of how to make this demand for uniform irons a general one can best be answered by the bodies who are already busily engaged in disseminating among the foundry world knowledge as to the possibilities of working on a basis of chemical analysis, and when the work of the technical societies and the technical Press has had a little more effect, we shall doubtless see something of a united effort to the desired end. In the meantime we should like to know whether the pig-iron makers, against whom this charge of stubbornness is laid, have ever been seriously approached by any responsible body representing the foundry world, with a view to having the various difficulties in the case discussed and representative opinions stated. We cannot help thinking that there are some makers, at least, who would be quite open to consider the matter if approached by such a body as we have cited.

Regarding the opinion expressed by one speaker at the Birmingham meeting, to the effect that chemical analysis was not necessary for pipe-founding, and that the whole thing resolved itself into a commercial question, we are quite in accord with the latter sentiment. The commercial question is at the root of the whole matter, for unless the founder produces castings up to a certain standard he stands the risk of commercial extinction. But as to pipe founding being exempt from the application of chemical analysis, that is quite another matter, for unless only such castings as rain-water pipes, and similar work which has not to stand any strain be included, the question of the composition of the iron is of great importance. How does the speaker referred to propose to produce sound pipe castings that have to stand steam, gas, or water pressure, and perhaps be machined to some extent, if he disregards the composition of his metal? This class of work, it is generally considered, calls for particular attention, and should give a good opening for the chemist and his services.

Corrosion of Iron and Steel.

In the course of a paper on this subject read last month before the Cleveland Institution of Engineers, Mr. Edward Crowe, of the South Durham Steel and Iron Company, said that the corrosion or rusting of steel was in itself a complex problem, and to account for its destructive action there were three principal theories:—(1) The carbonic acid theory; (2) the peroxide theory; (3) the electrolytic theory. Corrosion might take place almost imperceptibly; on the other hand, it might proceed with alarming rapidity.

Continuing, the lecturer said:—"The result of numerous experiments and investigations by various authorities is that the corrodibility of steel is affected by the presence of alloys. Aluminium, manganese, antimony, and arsenic, when alloyed with iron or steel are said to increase the liability to corrosion. Nickel, cobalt, tin, copper, chromium, and phoshorus decrease the liability to corrosion. Corrosion tests have been carried out by Mr. F. Saniter with both steel of ordinary ship quality and steel containing 3½ per cent. nickel. The corrosive medium was ordinary sea water.

"The samples of plate were drilled through their upper edges and suspended on glass rods in order that there should be no question of galvanic action as between one sample and another. The total time of the tests was five months. Eight samples were cut from nickel steel plates and eight from West Hartlepool ship quality steel plates. The average percentage of weight lost by corrosion from the nickel steel plates was 0.878, equalling a loss per square foot, of 343 grains. The average loss with the mild steel plates was 0.903 per cent., or 353 grains per square foot. The protection afforded by even 3½ per cent. of nickel was proved to be so slight that it can be ignored for all practical purposes so far as its influence on corrosion is concerned.

"Mr. J. E. Stead and others have conclusively proved that copper alloyed with steel protects it from corrosion, but the above cited tests tended to show that the small amount of copper found in commercial steels exerts no beneficial influence of any practical value. Phosphorus is a powerful antidote to corrosion. Diegel found that mild steel plates immersed in sea water lost in weight by corrosion in inverse proportion to their phosphorus contents. He also experimented with nickel steel plates and found that steel containing 6 per cent. nickel and over showed scarcely perceptible signs of corrosion after twelve months immersion, whereas steel with 0.02 per cent. nickel lost 6 grammes, on 16 square inches of surface.

It would appear that so far as our present knowledge goes there is no suitable constituent which, when alloyed with steel, will afford adequate protection against corrosion. The only method, therefore, is to apply a protective covering.

Heroult Steel Process in America.

The United States Steel Corporation has decided to introduce the Héroult electric furnace and steel process. One 15-ton Héroult furnace is to be in-

stalled at the South Chicago Works of the Illinois Steel Company, and one 15-ton furnace at the Washburn & Moen plant at Worcester, of the American Steel & Wire Company. Probably a furnace at Homestead will follow.

This decision is likely to result in developments of considerable importance. The largest Héroult steel furnaces installed in the past have a capacity of five tons. The largest steel furnace built anywhere so far (one of the Röchling-Rodenhauser type in Germany) has a capacity of eight tons. The Héroult furnaces of the Steel Corporation will have a capacity of 15 tons. This is admittedly only a beginning and the erection of 30-ton furnaces is contemplated when sufficient experience has been gained with the 15-ton size. In the two American steel works in Syracuse and McKeesport, where Héroult furnaces have been installed in the past, the object has been to replace the crucible process by the electric furnace, to make special steels electrically. At South Chicago and at Worcester the Héroult furnace enters into a wider field, as the steel is intended specially for rails and wire.

Engineering Trade Regulations.

In the House of Commons, recently, MR. H. SAMUEL, Under-Secretary to the Home Office, asked leave to introduce a Bill—"To make better provision for the safety and health of persons employed in certain building operations and engineering works, and purposes connected therewith." The Bill, he said, touched very closely the interests of a large section of the working population. It was well known that deaths from accidents in engineering works were excessive in number, and especially those due to explosives. The trade also was exposed to an industrial disease known as compressed-air illness. In the past Home Office regulations had been of immense value in protecting the lives and health of the working classes, and he trusted similar beneficial results would follow the passing of this Bill. Leave having been given, the Bill was brought in and read a first time.

Trades Disputes (Arbitration) Act, 1909.

A Bill has been presented to Parliament by Mr. Cleland to promote arbitration in trade disputes, which has the support of many prominent members. It provides that in all cases of industrial disputes or apprehended disputes, it shall be lawful for the Board of Trade, at the request of either party, to make provision for the settlement of any such dispute by arbitration as provided by this Act. On the receipt of any such request, the Board of Trade will forthwith take steps for the establishment of a court of arbitration to be constituted of members nominated in the following manner:—(*a*) Two by the employers; (*b*) two by the workman; and (*c*) one by agreement between the parties to the dispute, or failing agreement, by the Board of Trade, and the member so nominated shall act as chairman of the court of arbitration. The award of the court is to prevail for not longer than three years.

Britannia Metals.

The once familiar alloys known as Britannia metals have of late appeared to fall out of use to a great extent. This, however, is not the case, for the greater part of the goods made of these alloys are now silver-plated, and pass under other descriptions. So far from being used less, Britannia metal is used to a much greater extent than formerly, though it may be sold under another name, and without the original surface showing. The non-corrosive properties of Britannia metals constitute a valuable feature for many purposes, for, since there is no lead in its usual composition, the danger involved in the use of that metal is eliminated. The alloy consists of tin and antimony and small quantities of other metals, the composition varying slightly with almost every maker.

The following are some of the mixtures as quoted by one authority:—

Tin.	Antimony.	Copper.	Zinc.	Bismuth.	Lead.
94	5	1	—	—	—
90	6	2	—	2	—
90	7	3	—	—	—
89.3	7	1.8	—	—	1.8
85.5	9.7	1.8	3.0	—	—
75.0	8.5	—	—	8.0	8.5
90.6	9.2	0.2	—	—	—
92.0	6.2	1.8	—	—	—
92.2	5.9	1.9	—	—	—
92.8	5.4	1.8	—	—	—

The difference between the variously constituted alloys of the class which are in general use is not great, the first three constituents quoted in the above table being the essential features.

The presence of copper produces a harder and less ductile alloy, and has an injurious effect if used in more than small quantities. Copper is necessary, however, since the Britannia metal must be sufficiently hard to be not easily distorted. The antimony also serves to harden the tin, which would be too soft for the purposes to which the alloy is applied; it also makes the metal more easily worked and enables it to take a finer polish. Zinc and iron also increase the hardness of the alloy, but these are not desirable constituents. Lead, if added in small quantities, assist in obtaining a very fluid metal if such is required for fine cast work, but since the effect on the colour of the Britannia metal is not good, very little should be used; in fact, the majority of mixtures in common use do not include lead as a recognised constituent. A mixture extensively used in the United States for plated hollow-ware consists of a tin 92 per cent., antimony 6.2 per cent., and copper 1.8 per cent.; this mixture casts very well in metal moulds. Another popular mixture is tin 92.2 per cent. antimony 5.9 per cent., copper 1.9 per cent.

It is scarcely necessary to state that if the best results are to be obtained either in casting or stamping this alloy, the constituent metals should be of the best and purest qualities.

The usual method of procedure when making the mixture is to melt together equal parts of tin and copper, this being poured into small bars that can be easily broken for re-melting. This will readily mix with the remaining tin and antimony. Owing to the high melting point of copper, a plumbago crucible is necessary.

This first copper-tin mixture or "hardening" can be made in quantities sufficient to keep a stock of, so that only the one melting is necessary when casting is required to be done. The mixture then must be calculated on the contents of the "hardening," sufficient of that being used to give the desired copper content and the amount of tin in it being allowed for in weighing the tin to be added. In the final melting the antimony and the "hardening" should be placed in the bottom of the melting-pot and the tin on top.

The best castings are obtained from brass moulds previously heated and coated with lamp black. The pouring temperature should be as low as is compatible with good casting, and, therefore, since the temperature of the melted metal is higher than this point (owing to the antimony and the hardening) it is good practice to cool the metal with scrap, the whole being then thoroughly stirred. An excess copper is to be avoided if easy casting is desired, for the melting temperature is thereby raised considerably. Variations in copper and tin contents will be found necessary, however, when a harder or softer metal is desired.

An Up-to-Date Black Country Steel Foundry.

Metallurgists' Visit to the James Bridge Works.

The members of the Birmingham Metallurgical Society, which includes a number of local foundrymen, paid a visit, by the permission of the directors of F. H. Lloyd & Company, Limited, recently to the James Bridge Steel Foundry. Among those who took part in the visit were Messrs. I. S. Lester, F. M. Thomas, H. H. Cooke, W. J. Rees, P. T. Bailey, C. F. Davies, F. Bishop, H. S. Cattell, S. Lamb, and T. F. Day.

The visitors were received by Mr. J. Hemming, managing director, and Mr. D. C. Lloyd, another member of the Board, and were conducted through the works, where they witnessed a number of interesting operations in progress.

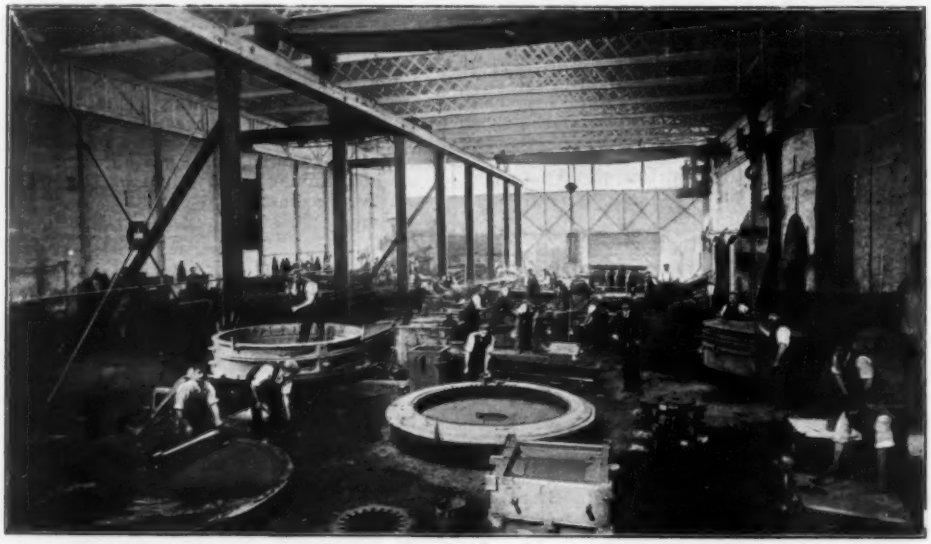


FIG. 1.—FOUNDRY FOR LARGE CASTINGS: JAMES BRIDGE STEEL WORKS.

The James Bridge Steel Works were founded in 1880 by Mr. F. H. Lloyd, the present Chairman of the Company. When the works were started only forty men were employed. The original purpose of the works was the making of small ingots and castings. The ingot trade, however, was not destined to have a very long career, and in 1882, or thereabouts, the chief production of the works was stockless anchor heads and other castings of that type. This trade ceased in its turn to be remunerative; but the directors of the Company again rose to the occasion, and developed the works in the direction in which their trade has ever since continued to progress.

The business was formed into a limited company in 1888, but the capital was privately subscribed, and the firm is still a private limited company. Among its productions are steel castings for engineers, and for every branch of trade in which steel is used—rolling mills, mining machinery, hydraulic plant, boiler work, wagon work, bridge building and other constructional work, tramway points and crossings, hauling gear, etc.

In the year 1893, extensions were necessary, and two shops were built, each having two bays, and equipped with modern cranes and appliances.

In the year 1897, two new Siemens' furnaces of ten tons capacity were added to the plant. The whole of these additions were carried out to the designs of Mr. J. W. Hall, A.M.I.C.E., who at that time was managing director of the Company.

The original directorate consisted of Mr. F. H. Lloyd, Mr. J. W. Hall, and Mr. J. Hemming. In 1898, Mr. Hall having seen through these important extensions of the works, retired, and was succeeded as managing director by Mr. Hemming. Mr. J. Fellows, and Mr. S. J. Lloyd also joined the Board.

A large new machine shop was erected in the year 1904. This addition was rendered necessary by a change which had been going on in the character of the work produced. In the meantime, other developments were gradually becoming necessary, and owing to the demand for small castings, it became necessary to adopt processes for producing these more rapidly. Therefore, in 1907, two new shops, each nearly 200 ft. long and of 40 ft. span, were erected, and equipped throughout with electric power. This was not the first introduction of electricity into the works, electric cranes and motors having been adopted in 1900. About the time of the extension in 1907, the Board was joined by Mr. G. W. Summers and Mr. D. C. Lloyd. The latter, who is the son of the founder of the business, had been for some time secretary to the Company, and he is now assistant-managing director. The erection of the new shops was commenced in November, 1907, and in May, 1908, experimental castings were being produced. Two side-blown converters have been put down here, with all the necessary equipment in the most up-to-date

form. The lifts and blowers and other auxiliaries are electrically driven. Each of the converters has a capacity of 40 cwts., and is capable of dealing with two charges an hour.

The works have an area of 14 acres, about four of which are covered with buildings. They are exceptionally well provided with railway accommodation, as they adjoin one of the main lines of the London and North-Western Railway. Private sidings run all round the works, and the arrangements for the reception of material and the delivery of goods are such that the cost of handling is reduced to the lowest percentage.

The pattern shops are extensive, while the machine shops are capable of machining castings up to 12 or 15 ft. in diameter. Among the many important contracts which the firm has executed may be mentioned the large construction work for dock extensions at Gibraltar, and at Keyham Harbour at the beginning of the present century.

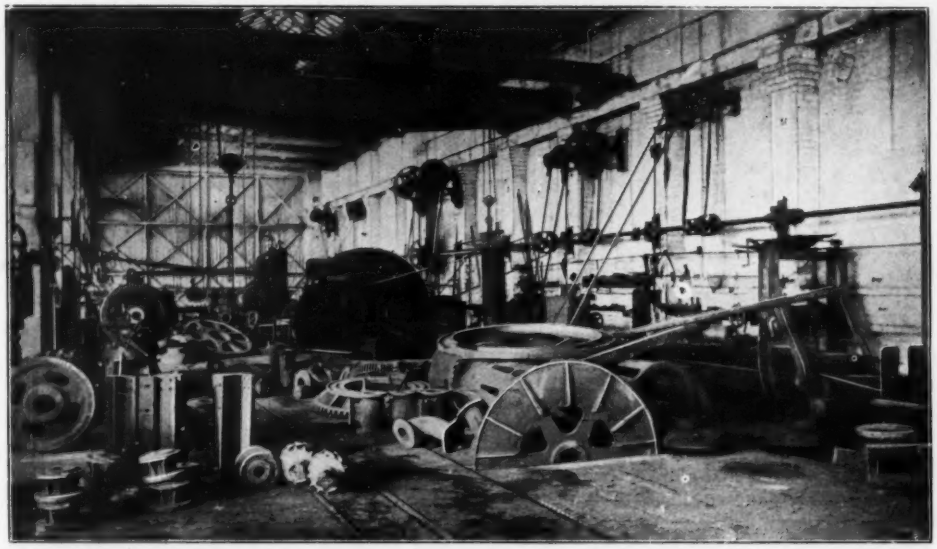


FIG. 2.—MACHINE SHOP: JAMES BRIDGE STEEL WORKS.

FIG. 3.—FOUNDRY WITH BESSEMER PLANT: JAMES BRIDGE STEEL WORKS.

The visitors from Birmingham were conducted by Mr. Hemming and Mr. Lloyd first to the pattern shop, after which they visited the new shop, and examined the side-blow Bessemer plant. Two small charges were dealt with, and run into a number of small castings. In the adjoining shop they saw two

charges run from the Siemens' furnaces into a number of heavier castings, and they also spent some time inspecting the arrangement of the machine shops, in one of which was also to be seen in operation the electric welding plant which the firm has for some years had in use.

One of the firm's particular specialities is the production of machine-moulded wheels. A considerable number of wheel moulding machines are in use, most of them being of the Whittaker type, and wheels varying in diameter from 8 in. up to 13 or 14 ft. are so produced. The teeth of the wheels are all designed to one standard, unless special requirements are made, and in numerous cases the firm have wheels at work which have been constantly in operation for the last fifteen or sixteen years. Tensile and bending tests are made daily on the various productions, and though the usual demands are about 28 to 32 tons, with an elongation of 15 per cent. it is not an uncommon thing for the firm to fulfil the requirements of engineers asking for 20 per cent. elongation. Castings are produced with tensile tests as high as 50 or 55 tons, but the general run of work that was seen by the party was between 28 and 35 tons tensile strength, and would have endured bending tests of 45 to 90 degrees.

The illustrations herewith reproduced depict some of the departments of the James Bridge Works.

Pig-Irons and Their Use.*

By E. Adamson.

The various pig-irons made can be divided into three classes or families:—

(1) Hematite, which is used in the manufacture of steel by the acid process, and also for castings which have to stand great expansion and contraction, such as ingot moulds, furnace doors and other parts which are subject to continuous heat. The chief feature of hematite is its low phosphorus, which in this country is always in the second place of decimals. Hematite is also used as a mixing iron in foundries, when toughness is required in the castings, and the lean numbers are also used as mixing irons in the forge. Malleable pig-iron for cast malleable is also made from the hard numbers of hematite.

(2) Foundry and forge irons are another class. What may be termed the ordinary foundry and forge irons contain phosphorus 1.00 to 1.50, according to the district where they are made, which, of course, to some extent at any rate, governs the ores used. Manganese in these irons also varies from, say, 0.25 up to 2.00, according to the ores used. There is another section of these irons which may be called special irons, such as cold blast and refined irons. The phosphorus in such irons rarely exceeds 0.60 and the manganese 0.75. Silicon and sulphur in these irons and, in fact, all irons, vary according to grade and manufacture. These irons are also used in the puddling furnace for better qualities of irons, both before and after refining.

(3) The third class of pig-iron, commonly called basic, is used in the manufacture of steel by the basic process—and comprises usually irons containing high phosphorus, say, 2.50 to 3.00 per cent. These irons are also very low in silicon, rarely exceeding 1.00. It has been found in improved basic practice that it is not necessary to have such high phosphorus, especially when dealing with molten metal, and higher silicon irons can also be used; hence many of the basic irons are as low in phosphorus as 0.80, particularly in America, and the higher silicon irons, commonly known as foundry irons, are now largely used in the manufacture of basic steel.

The above are the three great divisions of pig-irons, although there are many sub-divisions, particularly in the first and second divisions, such as charcoal cold blast, cold blast (fuel, coke), semi-cold blast, refined irons, etc.

* Abstract of Paper read before the Staffordshire Iron and Steel Institute, February 20, 1909.

Total Carbon.

In the blast furnace it would be impossible to obtain the necessary chemical reactions to reduce the ore to metallic form without the use of carbon; that is the case even in the electric furnace. In the blast furnace, however, a large excess of carbon is necessary, because of the actions and reactions between the carbon and the oxygen of the air as well as that of the ore, and carbon is used in the form of charcoal, coal, and also coke—its most common form. Carbon has a great affinity for iron, but there is a maximum percentage, termed the saturation point, which iron will hold. Considering first the question of pure iron, or rather commercially pure iron to be accurate, Saniter obtained the highest saturation point, namely, 4.81 per cent. carbon in the iron when cold, and it would appear the higher the temperature the higher the saturation point; hence molten metal at high temperatures can contain a much higher percentage of total carbon in solution than it can hold in its cold state. In the molten metal all carbon is understood to be in combination, but as it cools down the carbon is thrown out of combination, or precipitated as graphite, the excess of which above the saturation point is thrown out as "kish"—usually found in rich iron on the top of the pig. This saturation point of carbon and iron is increased or lowered according to the percentage of the various impurities. Total carbon has a great influence on the tests of cast iron, for it is generally accepted that the lower the total carbon the higher the test, and a rich No. 1 hematite of, say, silicon 1.00 would probably have a total carbon of 4.25, which would show a very large percentage of graphitic crystals. It will be seen, therefore, that such an iron would not give the same test as an otherwise similar iron of T.C. 3.00.

There are further points of interest. The higher the total carbon the longer is the iron in solidifying. It is a common fallacy that by melting pig-iron and steel scrap in the cupola the total carbon is thereby lowered—as a matter of fact the iron picks up carbon from the coke even in the cupola. Analyses of old cold blast irons have been published showing T.C. 2.00 or thereby, but this can hardly be correct, as even

twenty years ago cold blast irons showed above 3.50 T.C.

Combined Carbon.

Combined carbon is that carbon left in combination with the iron after the graphite has separated out, and it has two forms or carbides—pearlite and cementite. The percentage of C.C. as pearlite varies slightly according to the contents of the other impurities, but chiefly of the phosphide eutectic. It may be taken as a general rule that C.C. 0.80—0.85 is all pearlite, known as Fe_2C+Fe (=C 0.90 in pure iron and carbon), but above this cementite—called Fe_3C (= about C 7.00)—makes its appearance, in which form the remainder of the C.C. would be found. As the C.C. increases so do the ratios between pearlite and cementite.

It may be taken that the harder the iron the higher the combined carbon, and the softer the iron the lower the combined carbon, which may be considered the predominating partner in its influence upon the mechanical tests of cast iron, but it has yet to be shown how to produce any given percentage in the blast furnace at will. In steel it is easy to obtain any percentage at will, but there are so many other influences at work in cast iron that it has been impossible, so far, to accurately produce any required percentage even in castings, for it will vary somewhat according to the different thicknesses in one casting, owing to rate of cooling. Certain it is that temperature plays a very important part in reducing the percentage of combined carbon, for the longer the metal takes to cool the lower the C.C., which also varies in the same cast of iron from the blast furnace. For instance, to take an extreme case, some years ago two pigs were cast from the same ladle, both were cast in sand, one (*a*) was allowed natural cooling, and (*b*) was so covered as to considerably retard the rate of cooling, with the following result:—

	T.C.	G.C.	C.C.
(a) Natural fracture, spotted white ...	3.30	0.10	3.20
(b) Slow-cooled fracture, grey forge ...	3.30	2.58	0.72

In this case (*b*) would be at the recalescence point of graphite for a very much longer period of time than (*a*).

The usual annealing temperature is about 900 degrees, or about 400 degrees below the melting point of iron used for annealing, and perhaps 200 degrees to 250 degrees below the recalescence point of graphite. The chief reason of annealing is to convert the C.C. into a form of graphite called "temper" carbon, which is successful even at these low temperatures, when the iron is perfectly solid, for it does not reach even the pasty or intermediate stage at annealing temperatures.

Combined carbon in the pig-iron or grey part of the casting appears to govern the chill of cast iron—for as the C.C. increases so does the depth of chill.

Graphitic Carbon.

There are three distinct forms in which graphite separates out, each of which is produced at different temperatures, and it is undoubtedly largely the appearance of these forms of graphitic carbon which decides the grade of fracture of pig-iron showing different crystallisations of the iron to the eye. It is generally assumed that each re-melt of pig-iron in the cupola changes it a grade, but this is not necessarily so in *all* cases—it entirely depends upon the crystallisation *before melting* and upon the temperature at which the iron is melted, independent of any impurities; that is to say, it is possible to melt certain irons in the cupola, and in spite of the slight oxidation of certain impurities and slight increase of sulphur, the crystallisation, hence the grade, can be retained.

"Kish" has already been referred to as the excess carbon present in molten metal in solution, above the saturation point of iron in its cold state. This excess is thrown out as free flakes of graphite, and this separation goes on even after solidification. "Kish" is objectionable in steel manufacture. Under certain conditions it can be formed, and gets into the slag, from which it must be removed before the metal can be treated—hence it considerably retards working—and it appears to be more difficult to remove from the slag in the free state than from the metal in solution as carbon.

The percentage of graphite has a very marked effect on the strength of pig-iron, because the larger the percentage the less the areas of Fe. in intimate contact, which causes weakness as distinguished from the brittleness of, say, white iron. The formation of the crystals also has its influence on the tests, and after C.C. the next most important factor to consider in the question of mechanical tests is the crystallisation of the iron. Experience also shows that the crystallisation of the iron and the percentage of graphite is an excellent guide as to whether an iron will melt hot, absolutely regardless of the percentage of other impurities, pointing to a difference in thermal values of the different forms of free carbon. Another observation which points in a similar direction is that a rich iron does not come to "nature" so quickly as a lean one in the puddling furnace.

Silicon.

Under old conditions of working the blast furnace on regular grades of ore and regular burdens, with low blast pressures and temperatures, it may have been quite correct to say the higher the silicon the lower the sulphur, and conversely the lower the silicon the higher the sulphur. This is generally believed in foundry circles, but it can only be taken in a very general way. Modern conditions of working with higher blast pressures and hot blast, hence higher temperatures, have completely altered this long-held theory, and it is now possible to obtain a No. 1 iron of under Si. 1.00, of sulphur as low as iron containing Si. 5.00. Such irons would require very careful handling in the foundry, and the fact is mentioned merely to emphasise the possible variations in the chemical, as compared with the physical, condition of pig-iron; in fact, silicon can vary in a No. 1 as much as over 6 per cent. between the minimum and maximum. From this it will be seen that fracture alone is no guide to silicon contents. To further illustrate, I have made refined grey iron—of fractures in this district called No. 2—of silicon 0.40, and I have also made hard mottled pig-iron—not malleable—with silicon 0.15. According to general ideas these irons should have been white in fracture, but I could almost undertake to select an iron, and by continual re-meltings reduce the silicon to under 0.10, and the fracture would still be nearer grey than white.

Silicon is looked upon as a softener. So it is within certain limits, but this idea can be carried to excess, and these limits entirely depend upon the physical condition of the other irons used along with high silicon irons, and in fact also depend, to some extent, upon the physical condition of the silicious iron. Silicon raises the melting point of cast iron, and it is also noteworthy that the higher the silicon the more rapid apparently is the fall in degrees of temperature. Professor Turner has shown that silicon considerably retards the rate of cooling at the points of recalescence. Silicon also lowers these points of recalescence, and causes a greater evolution of heat, the graphite having a greater opportunity to separate out.

Silicon reduces the saturation point of iron and carbon. Commercially pure iron, free from silicon, can hold carbon 4.81, but ferro-silicon of, say, 16.00 per cent. would have probably under 1.00 per cent. carbon, and electrically made ferro-silicon of high percentage is practically free from carbon. It has been claimed that silicon and carbon combine to reach a total saturation point of 15 to 16 per cent.—carbon having a value equal to $3\frac{1}{2}$ times silicon—and above this combined saturation point the carbon is thrown out as "kish." This may be true under the conditions in which the experiments were made, but alter the conditions, and this "rule" does not hold. Personally, I have seen iron of which $T.C. \times 3\frac{1}{2} + Si = 1.48$ carbon and silicon saturation point. The total S.-P. and Mn. in this iron was only 0.053, so that nothing was present, chemically, which would alter the saturation points. I have also had iron where $T.C. \times 3\frac{1}{2} + Si = 17.82$ which chemically had nothing present to alter the saturation points. The only explanation is a thermal one.

In the manufacture of acid steel silicon is an important element, as it makes the slag and thereby governs the amount of scrap which can be used, hence is an important factor in the total carbon of the bath when melted. In basic steel the lower the silicon the better, because the higher the silicon the more lime is required, and in consequence the more the slag and the less easy it is to work the charge.

Sulphur.

This is not such a deadly enemy as it is made out to be in some quarters. Specifications of extremely low sulphur, which is obtainable only in rich irons and also expensive irons, is one extreme, and disregarding sulphur contents is the other. Low sulphur gives excellent tests, particularly in deflection, but if it cannot be obtained in the ordinary run of foundry irons at a commercial figure—that is for the ordinary run of castings—then a moderate percentage is allowable without detriment to the casting, and sulphur 0.15, or thereby, would give a satisfactory casting, and would machine easily. In tests, tensiles of nearly 16 tons have been obtained with S. 0.141. For special work it is a different matter, tensiles are not the only tests required. The lower the sulphur the higher the deflection, which is a very important test. The highest deflection which I have obtained was 0.75 in., with sulphur 0.042 in the test bar.

Sulphur undoubtedly hardens iron by retaining carbon in combined form. For instance, if we take pig-iron of identical composition, chemically and physically, and add thereto varying percentages of sulphur by melting, say in a crucible, under precisely the same temperature and other conditions, it will be found that the increase of sulphur increases the degrees of hardness, and if the iron is of a sufficiently lean fracture to begin with no doubt sulphur 0.50 might turn grey iron white, but because sulphur has had this influence under these particular conditions, it by no means follows that this given percentage of sulphur will apply in every particular case, for, as a matter of fact, the degrees of hardness entirely depend upon the percentage of C.C. There are many instances of malleable castings of S. 0.40 giving excellent results, showing that heat treatment at even comparatively low temperatures overcomes to some extent the hardening effect of sulphur, for even 0.40 per cent. has not prevented the precipitation of free carbon, and its partial elimination on the skin of the casting, whilst every ironmaster has occasionally met with soft grey iron containing high sulphur.

In chill castings the higher the sulphur the deeper the chill, but a "sulphur" chill is not a desirable thing.

Phosphorus.

Phosphorus segregates in cast iron, more than in steel, into isolated patches not unlike currants in a cake, which vary in number according to contents of phosphorus, and in size to cooling conditions. A pure iron of, say, P. 0.02 contains an occasional particle of phosphide of iron, which every section of the iron under the microscope will not reveal, but in an ordinary foundry iron containing P. 1.60 about one-tenth of the area of the iron is the phosphide, the other nine-tenths being a hematite base.

Professor Turner has shown that phosphorus considerably retards the rate of cooling, particularly at the recalescence points. Because of this carbon has, of course, more time to separate out, and in the non-phosphoric areas the combined carbon would be lower than might be expected if the iron contained no phosphorus, whilst the graphite would be higher, as also the total carbon, in these areas. The phosphide in the form in which it is found in pig-iron is probably a mixture of Fe_3P and Fe_4P, and does not appear to take up carbon, hence the areas in foundry irons capable of taking up carbon are reduced, and therefore also the total carbon of foundry pig-irons as compared with hematite is lower.

On the question of hardness, that of hematite depends upon the combined carbon, but in foundry irons there is in addition the hardness of the phosphide. These phosphides also cause weakness, and have a distinct tendency, in degrees, to lower the transverse and deflection tests of cast iron. The effect on steel is, of course, similar.

Phosphorus, like Si., appears to cool more rapidly in degrees temperature per minute, the fall increasing with increasing phosphorus, and having a peculiar effect on the chilling properties of cast iron; for whilst it reduces the depth of true white chill, it does not appear to materially decrease the depth to which the chill "mottles off." In this matter it shows phosphorus as a softener.

Phosphorus is not eliminated in the acid steel process, but is frequently taken down to traces in basic steel.

Manganese.

Manganese retains carbon in combined form as carbide of manganese, and when present as sulphide of manganese it counteracts the effect of sulphur. The higher the Mn. the higher the C.C., hence the harder and whiter the iron. Mn. does not appear to have any ill effect on castings up to 1.00 per cent.; it does not lower the transverse test up to this point, but it may slightly lower the deflection. This remark applies to close irons for high tests, but the influence on softer irons may possibly be somewhat different. The higher the manganese the longer the metal retains its initial heat, or otherwise gives "life" to molten metal. Further, Mn. has a distinct influence in increasing the depth of chill.

Tests.

Sufficient has been said to make it clear that no combination of chemical analyses of Si., S., P., and Mn. can be relied on to obtain high tests, nor can any such combination be given which will be of any real value unless under exactly similar conditions. It seems to be generally accepted, amongst those who have had any practical experience, that irons of the same analyses do not give the same tests, but it may not be generally known that irons of widely different analyses have given, consistently, practically identically the same tests. The following table, however, from West, will show this to be correct:—

		Si.	S.
A	Pig	1.25	0.035
	Casting	1.15	0.070
B	Pig	2.86	0.040
	Casting	2.67	0.046

No.	Transverse.	Deflection.		Strength in lbs.	
		A.	B.	A.	B.
		ins.	ins.	lbs.	lbs.
1	½ × 1½	0.29	0.35	110	164
2	½ × 1½	0.25	0.03	320	344
3	½ × 1½	0.21	0.24	550	530
4	½ × 1½	0.18	0.18	860	920
5	½ × 1½	0.15	0.14	1,260	1,208
6	½ × 1½	0.14	0.12	1,600	1,640
7	½ × 1½	0.12	0.11	2,240	2,320
8	1 × 1½	0.10	0.10	2,900	2,860
9	1½ × 1½	0.08	0.10	3,600	3,500

This clearly demonstrates that anaylses as at present understood cannot be relied upon.

Grading.

The British method of grading is, of course, by fracture, and I was pleased to hear Mr. Sydney G. Smith, a practical foundryman of many years experience, say recently before the Cleveland Institute of Engineers, "This method is now condemned as unreliable, but is it so unreliable." Many practical foundrymen will echo this sentiment. Grading by fracture only amounts, in effect, to grading by the carbons, but the appearance of the fracture itself does not give sufficient information, because for one reason, the saturation point of Fe and C. is increased or decreased according to the percentages of the various impurities, and also by temperature. For instance, I have known a rich No. 1 low-sulphur hematite with Si. 0.67, and another with Si. 6.70, and the difference in total carbon would be 1.00 to 1.25 per cent.

Much has, on the other hand, been said about grading by analyses only, by which I have always understood, and still understand, the working to analysis absolutely regardless of the fracture of the iron, which is, of course, the opposite extreme of working to fracture only. It is common to human nature, when one thing has proved an apparent failure, to rush headlong to the other extreme, and it seems that this has been done on the question of grading by, and working to, analysis. In America this amounts to nothing more or less than grading by silicon and sulphur contents, the two most changeable elements, even on the same burden, in the manufacture of pig-iron in the blast furnace. Carbon is influenced by the temperature, and phosphorus and manganese depend upon the burden, running fairly regular on regular burdens. In irons made at the same furnaces from similar burdens, Si. and S. only are considered in America, perhaps because many of the furnaces use casting machines, *i.e.*, the pig is run into moulds, which chill the iron and the fracture is in consequence no great guide to physical condition, or the proper fracture on re-melting and casting into sand. Again, most of the American irons are low in Si., and for fine work silicious irons or low-grade ferro-silicon is used to give fluidity, and foundry practice in America is therefore totally different from the British, where Nos. 1, 2, and 3 irons can be obtained with silicons of 3.00 per cent. and over.

When pigs are cast in chills, grading by Si. and S. is perhaps the only thing to do, but, nevertheless, it is condemned in America by men of long practical experience. One of these gentlemen goes so far as to say that working on a silicon basis has been a decided disadvantage, and if persisted in will ruin the foundry industry. He further adds that correct mixing can only be done by experienced men, and grade analyses of Si. and S. are but of little value when test specifications have to be made. These remarks entirely confirm my own experience. Mr. George Hailstone also appears to agree that mixing can only be done by experienced men, for in his paper last December, in referring to technical institutions, he says they "do not pretend to teach a man his business, their object being to impart knowledge, which helps to throw light upon that which would appear otherwise mysterious."

My own experience is that it is necessary to consider not only the Si., S., P., and Mn., but also the carbons as partly disclosed by the fracture, and it is only practical experience in the close observation of the cause of the changes in fractures, and the effect on re-melting under various conditions, which gives any indication of what may be termed the physical condition of pig-iron. Here, again, there are many more actual grades than the five which represent our present method of grading. There are many subdivisions. Some close irons would perhaps apparently have a No. 5 fracture to a casual observer, but it is really, for mixing purposes, as soft as No. 1, and there are many apparently close irons which, when re-melted, show an open fracture.

The mistake commonly made by those who have been trained as chemists, purely and simply, whether in a steel works laboratory where analysis is the primary consideration, or in a technical institution, is that they unfortunately have got the idea that chemistry is the sum and substance of metallurgy. They enter the iron foundry with large ideas, and in many cases give a trusty practical man to understand that his training goes for nothing. The result is that they are thrown on to their own resources, and disaster immediately follows. Chemistry gets a bad name, and is condemned, as it has been in many foundries. Only last week I saw a large engine where a cylinder lining had been worn out in three weeks, and another, which had been in only a fortnight, was about done, whilst the previous one had been in nearly three years. All these liners were made by the engine-builder, but the two new ones were made on scientific chemical mixtures, whilst the other was made by a practical man with no knowledge of chemistry. Generally speaking, the one idea of this class of chemists, when stripped of everything, amounts only to consideration of silicon contents. Nor are they entirely to blame, for those by whom they are employed seem to expect that a youngster who has learned how to do a few simple analyses, and who may perhaps have attended a course of lectures in metallurgy, should be perfectly capable of giving all kinds of mixtures in the foundry. In fact, they are never given a chance, for their education in metallurgy is looked upon, both by their employers and themselves, as completed, whereas it has only begun. What is wanted in connection with the foundry is a practical metallurgist. He need not be a chemist, but he must be able to apply the results obtained by a chemist, and the wider his experience in metallurgical operation the greater will be his horizon. The chemist must be put into the foundry to learn, not to teach, and his advancement in knowledge will depend upon his own ability to absorb. Not until this is fully recognised on both sides will any true advancement be made in foundry metallurgical practice.

FLETCHER, RUSSELL & COMPANY, LIMITED, who are closing their Scotia Foundry, Pendleton, have decided to manufacture the whole of their specialities at the Palatine Works, Warrington.

A LECTURE was delivered recently at the Birmingham University, before the local Association of the Institute of Civil Engineers, by Dr. W. C. Unwin, on "Standardisation in Engineering Practice."

The Manufacture of Steel for Castings.*

By Dr. Bradley Stoughton.†

The growing scarcity of low-phosphorus ores, in comparison to the ever-increasing demand for them, is rapidly forcing upon steel manufacturers the only process available to them for the reduction of phosphorus. Whether this circumstance is or is not a benefit to the steel casting industry is one of the objects of this paper to study.

The Acid Open-hearth Process.

The distinguishing features of the acid open-hearth process for making steel castings are:—

(1) An acid slag with the consequent inability to purify the metal from phosphorus or sulphur.

(2) The amount of steel scrap used in the acid process is much greater than in the basic.

(3) Recarburisation may take place in the acid furnace, but must be effected in the ladle in the basic process.

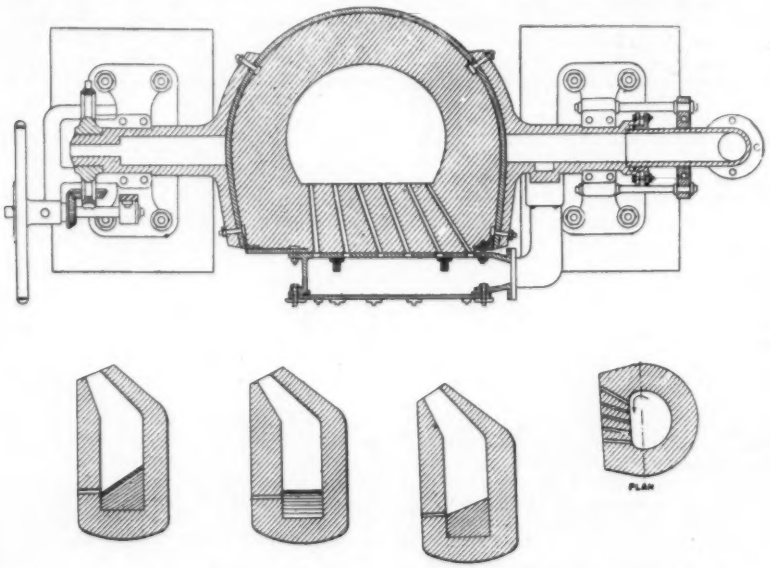
(4) The flexibility of chemical composition of open-hearth steel (both acid and basic) is very slight. Generally all the charge is "dosed" to the same composition and all the castings made from that heat must be alike. This greatly increases the difficulty of making steel castings of special carbon contents, or of alloy steels, because just enough castings to take the whole charge of a furnace, and no more, must be made ready from orders requiring the special material, and even then the scrap and risers must be kept separate in certain cases, as, for example, after making nickel steel.

(5) The waste of metal by loss and oxidation is less in the acid open-hearth process than any except the crucible process, and this is a potent factor towards economy.

(6) The fuel economy of the acid open-hearth furnace is greater than any process except the Bessemer.

(7) The time of operation in the acid open-hearth furnace is less than in the basic, chiefly because of its greater heat efficiency and its being more of a re-melting than a purification process. It takes nearly twice as long as the crucible operation, however, and many times longer than the Bessemer.

(8) The "campaign" of the acid open-hearth furnace before it is necessary to cool it down for repairs is nearly 1,000 heats, as compared with 350 for the basic furnace, and 20 to 1,000 for the converters usually employed for castings.



PLAN AND SECTIONS OF THE ROBERT-BESSEMER CONVERTER

(9) The cost of installation of an acid open-hearth furnace is greater than for any but a basic furnace. A furnace of 15 to 30 tons capacity will cost from £2,500 to £6,000, depending upon lay-out, etc.

(10) The cost of operation of the acid open-hearth is greater than the basic process, and less than the converter and the crucible.

(11) In quality, acid open-hearth steel stands above all except crucible, but for castings, acid steel has advantages over basic that do not apply when ingots are to be made and rolled.

(12) It must be observed that the acid process is also open to dangers resulting in bad quality of metal, prominent among which is that of over-oxidation during melting because there is so little reducing agent present.

The Basic Open-hearth Process.

(1) The basic open-hearth process employs a basic slag rich in lime—45 to 55 per cent., including mag-

* Abstract of a Paper presented before the Pittsburg Foundrymen's Association, U.S.A.

† Of Columbia University, New York.

nesia—with the consequent ability to rid the bath of phosphorus and an important amount of sulphur. The slag is large in amount, which reduces the heat efficiency of the furnace, and necessitates using a large proportion of pig in the charge, so that it shall melt easily. The slag also contains over 80 per cent. of metallic oxides, including often 20 to 25 per cent. of oxide of iron, so that the metal is likewise liable to be charged with oxide, lowering its quality and introducing a tendency to blow holes.

(2) The scrap used in the basic furnace is usually only about 50 per cent. of the charge, in order that there may be enough pig present to secure easy melting and furnish enough reducing agencies to prevent excessive oxidation of iron during melting.

(3) Recarburisation cannot take place in a basic furnace because the reducing agents added, especially silicon, will reduce phosphorus from the slag.

(4) The flexibility of the basic open-hearth process, both in chemical composition and tonnage of the product, is very slight. The flexibility in composition of product may be increased by using a tilting furnace, but these are costly to install and keep in repair.

(5) The loss of weight between metal charged and produced in the basic open-hearth process is greater than that of the acid process, but is only one-third to one-fifth of the converter process.

(6) The temperature of basic steel is sufficient for all castings over 100 lbs. in weight, and even smaller, if there are not too many of them to be poured at the same time, because then the length of time required for teeming makes the metal cool towards the end with the dangers of stopper troubles, etc.

(7) The heat efficiency of the basic furnace is the lowest of all those used for steel making, chiefly because the heat must penetrate a very bulky slag with low heat-conducting power in order to reach the metal.

(8) The basic open-hearth operation is also the longest of all, averaging perhaps an hour or so longer per heat than the acid process. This makes labour and fuel charges per ton high, and is the cause of the flexibility of the production being slight, when compared to the converter and crucible processes.

(9) The "campaign" of the basic furnace is only about 350 heats, after which repairs must be made which are more costly than those of the acid furnace, and much more so than those of the converter or crucible furnace.

(10) In cost of installation the basic furnace is highest of all, being substantially higher than the acid furnace on account of the greater cost for basic than for acid material. Add to the labour and fuel charges of the basic open-hearth the costliness of its repairs, and we have its chief items of expense, but the cheapness of the pig and scrap suitable for it more than make up the difference, so that the basic furnace is the cheapest one in which to make steel.

(11) The quality of basic open-hearth steel is believed to be lower than crucible and acid open-hearth steel. When compared with converter steel it seems probable that the basic steel would be preferred except for its liability to blow holes.

The Converter Process.

The distinguishing features of the converter process are:—

(1) An acid slag with the consequent inability to purify the metal from phosphorus or sulphur, and the resulting necessity of purchasing pig-iron low in these two elements, and therefore higher in price.

(2) The converter uses a relatively small amount of steel scrap—say 25 per cent. or so—being merely what can be melted with the iron in the cupola.

(3) Recarburisation may take place in the converter and this is a source of slight saving since there is a notable reduction of iron from the slag thereby. It also ensures a more perfect mixing and distribution of carbon and silicon.

(4) The flexibility of the converter process in the composition of steel produced is greater than that of any of the other processes. Its flexibility in regard to tonnage made is also one of its chief advantages, although here it cannot claim any superiority to the crucible process. One great advantage of flexibility in production, aside from allowing for fluctuations in demand, is the ability occasionally to make a few extra castings at short notice to oblige a customer, or to replace defective castings with minimum delay. The average time between heats will be 20 to 25 minutes, and it is possible to make from 25 to 30 heats in 10 hours, if desired.

(5) The waste of metal in the converter process is its greatest disadvantage and source of expense as compared with all the other processes.

(6) It is possible to get a higher temperature in the converter method with less cost for repairs and less wear and tear on the furnace than is the case in the open-hearth process, for the reason that the converter metal is made hotter than the furnace, while the open-hearth furnace is always hotter than the metal in it. It is said that this is one of the chief reasons why converter metal is especially adapted for the manufacturer of small castings, and also for its lesser liability to blow-holes, but there does not seem to be any good reason why metal made in a small open-hearth furnace, say of 5 tons capacity, should not be equally suitable for light castings, provided one is willing to endure the very high fuel costs that the use of such a furnace would entail on account of its poor combustion and the short life of ports which a short open-hearth furnace always has to endure. It has been argued that the high temperature of the converter metal is a danger, and source of "hot cracks" and defective castings, because of incorrect judgment of the casting temperature, but it is no more difficult to judge the temperature of the steel in the ladle from the converter than to judge the temperature of the flame in the open-hearth.

Characteristics of the Different Processes of Making Steel for Castings.

	Acid Open Hearth.	Basic Open-Hearth.	Converter.	Crucible.
Purification is	Acid	Basic	Acid	—
Amount of slag, per cent.	6 to 15	15 to 30	10 to 11	—
Steel scrap used, per cent.	85	50	25	—
Recarburise	In furnace	In ladle	In furnace	—
Can be operated	Continuously	Continuously	Intermittently	Intermittently
Flexibility in analysis	Small	Small	Great	Great
Flexibility in composition	Small	Small	Great	Small
Metal loss, per cent.	3	5	15 to 30	1 to 2
Metal or furnace, hotter?	Furnace	Furnace	Metal	Furnace
Fuel used, per cent.	25	30	15	125
Time of conversion	7 hours	8 hours	20 minutes	4 hours
Campaign in heats	1,000	350	20 to 1,000	Several thousand
Cost of installation	Large	Largest	Small	Smallest
Cost of operation	Medium	Smallest	Small	Largest
Danger of blow holes	Medium	Greatest	Small	Least
Quality of castings	Second	Lower	Lower	Best

(7) The time of the Bessemer operation is about 14 minutes, to which must be added that necessary for pouring the steel into ladles and pouring in a new charge. As it is customary in some shops to take the whole of the steel in hand ladles, there will be in such a case quite a delay between the operations. The short time of the conversion enables large-sized castings to be made occasionally, although the converter process is not suited to making regularly single castings whose weight is greater than the capacity of the furnace. Nevertheless, it is not unusual to make four-ton castings with one two-ton converter, saving the metal from the first blow until that from a second blow is ready, and six-ton castings are sometimes made with the same apparatus.

(8) The "campaign" of the converter will depend upon the type of vessel used; the lining in the neighbourhood of the tuyeres lasts only 20 to 25 blows, and in those converters made all in one piece—such as the Tropenas, the Robert, etc.—it will be necessary to put the converter out of commission and cool it down for repairs at the end of this period. In those steel casting converters made with removable bottoms, however, (Stoughton type), it is only necessary to change to a new bottom whenever the tuyeres are worn out and the upper part will last for 1,000 heats or more. Moreover, the removable bottom greatly cheapens and facilitates repairs, because those converters made all in one piece require a great hole to be cut in the lining of the side, in order to get at the part to be repaired, so that one removable bottom converter with one spare bottom has a daily capacity almost equal to three converters of the same size built all in one piece.

(9) The cost of installation of a converter with accessory apparatus will be less than that of an open-hearth furnace of equal capacity. How much less will depend upon the type of converter. For example, one must have at least three two-ton converters built all in one piece to equal in capacity one 15-ton open-hearth furnace.—The cost of the converters would be:—

	£
Converters and lining	1,000
Blower with motor	400
Cupolas and linings	190
	1,590

One two-ton converter with one spare interchangeable bottom would have almost as great a capacity and the cost would be:—

	£
Converter and lining	330
Spare bottom	75
Blower with motor...	400
Cupolas and linings	190
	995

(10) The cost of operation of the converter process is less than any except the basic open-hearth, for reasons already outlined, the chief item of expense in the converter process being the waste of metal. It is only fair, however, to deduct from the waste of metal a small amount in consideration of the saving in defective castings due to the freedom from blow-holes, in which respect the converter has a decided advantage over the basic open-hearth, and, to a less extent, over the acid open-hearth also. In making light castings there will also be a further saving by the converter process due to a smaller number of misruns and skulls.

(11) The quality of converter steel is about on a par with that of basic open-hearth steel. It will be higher in phosphorus, unless only the very purest metal is used for charges; it will, however, have the advantage of being higher in silicon, and much less liable to blow-holes. This latter feature is due partly to the higher silicon, but is no doubt increased by the high temperature of the converter metal, because it exceeds the acid open-hearth steel also in its freedom from blow-holes. No doubt the high temperature of the converter metal assists in freeing it from its dissolved gases, and also from oxide of iron which is an important cause of blow-holes, it being a theory maintained by several that the hotter the steel the more readily will the oxide of iron separate itself from its state of suspension in the bath.

The Crucible Process.

The crucible process for steel castings is characterised by the use of expensive raw material—which costs as much or more than the product of any of the other processes—high charges for crucibles, labour and fuel and a very low cost of installation, being only a few hundred dollars for the erection of a coal-fired crucible furnace. The quality of the crucible steel is higher than that of the products of any of the other processes—chiefly on the account of the protection of the metal from oxidation and contamination by fuel, as well as because of the small units in which the steel is made and the consequent necessity for care and attention.

CEMENT PASTE FOR STEEL PROTECTION.—A cement paste for protecting steel from gaseous fumes has been used by the Pennsylvania railway with success. The paste is composed of 12 lbs. pure red lead, 32 lbs. Portland cement, 4 lbs. linseed oil, and 2 lbs. dryer. This mixture should make a paste like putty, but if too soft, cement and red lead are to be added, and if too heavy, oil and dryer are to be added. The method of application is as follows:—(1) The iron or steel surface to be coated should be as clean of rust and foreign matter as it can be made, using either sand-blast, steel brush, chisel, or sand-paper for this purpose; (2) apply one heavy coat of red lead and allow it to set; (3) apply one heavy coat of Japan dryer; (4) apply paste on dryer while latter is green; do not allow Japan dryer to become dry before applying paste. The paste should be put on about one-eighth inch thick, rubbed with trowel and pressed around rivet heads and angle flanges by hand; (5) cover all with one coat of red lead. This last coat adds a great deal to the life of the coating, as it retards the hardening effect of the atmosphere on the paste. The life of the coating is said to be six years, and the cost for labour and material, including the cleaning of the metal, 4d. per square foot.

A MEETING of the Board of Conciliation for the Ironfounding Industry of Lancashire was held on March 23. at Manchester. Mr. R. Matthews presided on behalf of the Lancashire Employers, and Mr. Arthur Henderson, M.P., on behalf of the Ironfounders' Society. The meeting was held with the object of discussing a general reduction of moulders' wages in the Lancashire district. Ultimately it was agreed unanimously:—"That the wages of ironmoulders in the districts covered by the above Board should be reduced 1s. per week in time rates with an equivalent reduction in piece prices, except in those districts where no advances have recently been given, the reduced rate to come into operation the first full pay after Easter, 1909, namely, April 23 or 24, 1909."

Composition of the Modern Bronzes.*

Deoxidising Elements used in Copper Alloys.

By C. Vickers.

Under this head may be classed all alloys of copper which contain some metal or metalloid, the use of which in alloys has been possible only within recent years. The modern bronzes, therefore, comprise those alloys containing aluminium, silicon, magnesium, phosphorus, manganese and iron. These elements, with the exception of aluminium, are not used to form alloys of copper in the same manner as tin, zinc or lead, but act as deoxidisers of these alloys, increasing their tensile strength and ductility.

Taking these various elements in the order named above we will first consider aluminium.

Aluminium.

This metal when alloyed with copper forms the well-known aluminium-bronze, the introduction of which was a radical departure from the old time bronzes, but it was found difficult to cast, and as the demand for it never became sufficiently insistent to induce the founder to overcome these difficulties, the alloy fell into disuse, which was also the case with the copper-tin-aluminium alloys. At the present time, aluminium in copper alloys is confined almost exclusively to the copper-zinc series, forming aluminium brass. The content of aluminium in such brass is usually very small, compared with aluminium bronze, and is added to impart fluidity to the alloys more than for any deoxidising or strengthening qualities the aluminium may possess. A typical alloy is copper, 56 per cent.; zinc, 44 per cent.; aluminium, 6 ozs. This mixture being cheap and running exceedingly fluid has found great favour for making such plumbing goods as ferrules.

It is this property which aluminium possesses of imparting fluidity and preventing the oxidation of the zinc, thereby suppressing the smoke, which is such a disagreeable feature in casting yellow alloys, which has caused this metal to be so extensively employed for small brass castings, such as saddlery hardware, etc. An alloy used for this purpose is copper, 60 per cent.; zinc, 36 per cent.; lead, 3 per cent.; and aluminium, 1 per cent. Large castings are difficult to cast without dross, and various means are employed to overcome this difficulty. The most important feature, however, is to pour the metal at as low a temperature as possible. Aluminium is used in almost all the modern bronzes, the exception being silicon and phosphor bronze.

Silicon.

The use of silicon in the brass foundry is largely confined to making copper castings. It is used in the form of silicon-copper, which is supposed to contain from 10 to 30 per cent. of silicon. An analysis of one of the best makes showed only 9.63 per cent. silicon, the balance being copper. This was a brittle alloy and one-fourth of 1 per cent. would make copper castings solid. It is advisable though, in ordinary practice, to use 1 per cent. at least. The effect of silicon on brass is very similar to aluminium, in fact, it is difficult to tell whether silicon or aluminium has been used when the metal is in a melted state. Silicon is better than aluminium for many purposes in zinc alloys, as the castings do not run so drossy and are softer, but it cannot be used in the presence of lead, except when aluminium also is added. For all yellow brass castings free from lead, where strength and fluidity are desirable, silicon can be recommended. In an alloy of 60 per cent. copper, 40 per cent. zinc, the addition of 1 per cent. of 10 per cent. silicon-copper increased the tensile strength of a cast bar to 50,000 lbs. per square inch, which will compare favourably with manganese bronze cast in the same manner, viz., into a round bar moulded in the ordinary manner with a 3-in. cope, the metal being run straight into the casting.

Experiments have shown the writer that silicon possesses no great value in copper, tin or zinc alloys, even when used in minute quantities. When silicon is used in bronzes, zinc should be omitted. A bronze containing 5 per cent. tin and 1 per cent. silicon is a good alloy for trolley wheels. When lead is present in any alloy, silicon cannot be used. The casting will be coated with a white deposit as if lime-washed, and will be full of dross. For this reason silicon cannot be recommended as a deoxidiser in brass founding, as a small quantity will create havoc in scrap metals, as these metals always contain lead, and the castings will be drossy for the third and fourth melt, and will have to be proportioned in new metal to be used up.

Magnesium.

Magnesium is also used as a deoxidiser of copper in the proportion of 2 ozs. magnesium to 100 lbs. copper. The conductivity of such copper is high, but the castings are very liable to defects and cause considerable loss, as the defects do not show until the work is machined. One concern has partially overcome this difficulty by the use of a small quantity of phosphor-tin with the magnesium, about 6 ozs. to 100 lbs. of copper. Magnesium is an excellent deoxidiser for brass, but it must not be used too generously, as 2 ozs. to 100 lbs. of copper are sufficient. This should not be exceeded in brass. In an alloy of 65 per cent. copper, 35 per cent. zinc, 3 ozs. of magnesium were used. The metal did not run well, the castings being black and drossy. This was due to excess of magnesium.

Phosphorus.

This element is so well known to all brass founders that it needs no description. It is used either in the stick form as yellow phosphorus, or in alloy with either copper or tin. It is the best deoxidiser known in brass founding, being especially valuable in the copper-tin alloys, with which it forms the well-known phosphor bronze. The old style phosphor bronze was so rich in phosphorus that it would cut into the sand of the mould, much like water, and for that reason required special training of the moulder or furnaceman to gauge the proper casting temperature, otherwise the castings would be shapeless masses of mingled sand and metal. Of late the tendency has been to go to the other extreme, some writers contending that only just so much phosphorus should be used, as will remove the copper oxide from the metal. As this oxide is a variable quantity in every heat, it is

* Presented at the February meeting of the Pittsburg Foundrymen's Association.

difficult to put this theory into practice. It is stated, however, that 2 per cent. phosphor-tin (containing 5 per cent. phosphorus) is the maximum amount of phosphorus to use. In the writer's opinion this is not borne out by practice, as the strongest phosphor bronze contains more than twice that amount of phosphor-tin. An alloy of 90 per cent. copper, 5 per cent. block tin, and 5 per cent. phosphor-tin has been found to possess a tensile strength of from 38,000 to 42,000 lbs. per square inch, with an elongation of 22 per cent. A wall of this alloy, 3 in. in thickness, withstood a water pressure of 5,000 lbs. per square inch. In place of the phosphor-tin, yellow phosphorus was tried, the formula used being: Copper, 90 lbs.; tin, 10 lbs.; yellow phosphorus, 10 ozs. The tensile strength of this alloy was 36,000 lbs. per square inch. When the phosphorus was dropped to 5 ozs. the tensile strength fell to 22,400 lbs., which speaks for itself.

Manganese.

This also is a good deoxidiser for bronze, but it must be used in small quantities, not sufficient to discolour the castings. It strengthens the copper-tin alloys, if used with discrimination, but it will do more harm than good if not, as tin seems jealous of all the modern deoxidisers except phosphorus, and the writer has found that a combination of all these deoxidisers, in certain definite proportions of each, is necessary to obtain some results, because one will counteract the evil effects of another, producing a perfect deoxidation of the metal, and at the same time also freeing it from the weakening effects of hydrogen, nitrogen, and sulphur. Metal so purified is entirely different from the ordinary bronzes of the same composition, and combines the strength of the yellow alloys with the casting qualities and golden colour of the tin bronzes.

Mixtures and Deoxidisers.

An alloy of 90 per cent. copper, 5 per cent. tin, 4 per cent. zinc, 1 per cent. deoxident, possesses the same quality of tone when cast into bells as the standard alloy copper, 80 per cent.; tin, 20 per cent. The elimination of the gases in copper is the secret of the superior strength of the modern bronze, and the reason why two alloys of practically the same composition—as shown by analysis—differ so much in strength, elongation, etc., is that the maker of the better alloy had discovered how to remove the above impurities from his metal, while the other had not.

While manganese acts as a deoxidiser in the well known bronze or brass of that name, it will not of itself remove all the impurities in the metal. Consequently, when manganese only is used, it is not possible to obtain the maximum strength in the alloy, and to this fact must be attributed the failure of many brass founders to make a high-grade manganese bronze.

Manganese and copper unite readily to form alloys, provided the proper temperature is reached by the furnace. If 30 lbs. of copper are alloyed with 10 lbs. ferro-manganese the resulting alloy is white in colour, and will give approximately the following analysis: Copper, 80 per cent.; manganese, 16.3 per cent.; iron, 1 per cent. In making manganese copper it is usual to alloy them in the proportion of copper, 65 per cent.; manganese, 35 per cent. When zinc, lead and aluminium are added a silvery alloy is formed, variously known as "silver bronze," "manganese silver," or white bronze. This metal is superior in colour to German silver, does not readily tarnish, and will resist most acids. When higher percentages of manganese are used, exceedingly hard alloys result. The writer has made them so hard that they will readily cut glass and the glass will break along the cut. Manganese discolours brass and bronze. One-half of 1 per cent. manganese copper is sufficient to discolour brass, and the colour is dark brown approaching black. It can be used to advantage in all yellow brass, but just sufficient should be used to colour the castings a rich reddish brown. The improvement in solidity, strength and casting qualities is very noticeable.

Iron.

The last element on our list is iron. This metal is regarded more as an enemy than a friend by the brass-founder. That is because it is generally found too abundantly in brass, and causes lots of trouble in removing it, and when not removed causes dirty, shrunken castings. The earliest of the modern bronzes, however, owed their superior qualities to the iron they contained. The well known Delta metal, sterro-metal, Tobing bronze and Aich metal, were alloys of copper, zinc and iron. The greatest difficulty in making alloys with iron, is to get the iron to combine with the copper, as these two metals are difficult to alloy. Many founders imagine there must be a carrier of the iron, and manganese has been credited with this property, but this metal is much inferior to silicon in this respect. The only way to add iron is in the form of a salt of iron. In this manner we can make solid copper castings, as the iron is a deoxidiser of the copper, and such castings possess high conductivity, being very valuable for electrical work. An alloy of 55 lbs. of copper and 40 lbs. of zinc, containing about 1 per cent. iron, rivals manganese bronze in strength, and can be cast easily without the aid of aluminium, the castings being of a pleasing brown colour. Iron has also been found to greatly improve the tone of bells; it is also used in spring bronzes, as it imparts elasticity to the alloy.

Conclusion.

In conclusion, the superior qualities of the modern bronzes depend upon the small quantities of aluminium, silicon, magnesium, phosphorus, manganese, iron and occasionally sulphur they contain; to these they owe the qualities which distinguish them from ordinary alloys. The content of copper, tin, zinc, lead, etc., are easily determined by analysis. The founder who seeks to imitate a superior alloy for analysis will be wise to pay more attention to the "impurities" than to the easily determined metals which form the body of the alloy, for the body is of no special value if the spirit is absent.

CONNELLSVILLE COKE PRODUCTION IN 1908.—The production of coke in the Connellsville (U.S.A.) coke regions during last year showed a heavy decline as compared with the previous year. The actual production is quoted as 9,704,413 tons for 1908, the consignments for that year being 10,700,022 tons as against 19,029,058 tons in 1907, a decrease of 8,329,036 tons.

The total consignments of coke from the entire Connellsville region during recent years, together with the oven capacity and the average selling price, have been as follows:—

Year.	Total ovens.	Tons consigned	Average price.
1900	20,954 ...	10,166,234 ...	$2.70
1902	26,329 ...	14,138,740 ...	2.37
1904	29,119 ...	12,427,468 ...	1.75
1905	30,842 ...	17,806,526 ...	2.26
1906	34,059 ...	19,999,326 ...	2.75
1907	35,697 ...	19,029,058 ...	2.90
1908	37,842 ...	10,700,022 ...	1.80

It will be noted that last year's consignments were almost on a parallel with those for 1900, and little more than half those for 1906 and 1907.

Cupola Practice.

By M. Albütz.

Much has been written recently about the economy and efficiency of cupola practice, and one feels inclined to think that the more this subject is discussed, the greater the differences of opinion will become. It is not incorrect to say that there is not one branch in metallurgical and engineering practice where views differ to such a degree, and where—except in a few well-conducted iron and steel foundries—so little science is applied; where the term "modern shop-practice" seems to be an impossibility, and where business is carried on in such a conservative style, as in the majority of iron foundries in this country. It would be of great interest to know the reason why modern foundry practice has been left so far behind other branches of engineering, and why scientific appliances have found so little access to it.

About the end of 1907 there appeared in almost all the leading technical papers of this country an article, written by Mr. Bellamy, on the construction and equipment of modern iron foundries, which must have attracted the attention of anyone who is anxious to know something more about cupola practice. The same interest was aroused by an article which appeared in the FOUNDRY TRADE JOURNAL of April, 1908, on "Foundry Practice, with Special Reference to Marine Work," by Mr. Dalrymple, read before the Cleveland Institute of Engineers.

Before going any further into the subject I may mention that I have no connection whatever with either of these two authors, neither have I any personal acquaintance with them, but it seems to me rather unpardonable to let these matters pass by without any further discussion, and I have waited in vain for a long time past in the hope that someone else would give the subject closer investigation.

On drawing a comparison between the statements of the two authors, I may say in advance that those made by Mr. Bellamy seem to be somewhat misleading and of an exaggerated character, whilst those of Mr. Dalrymple are more in the line of ordinary cupola practice. Mr. Bellamy says that he is able to melt 10 tons of iron per hour in his cupola with an internal diameter of 32 in., and with a coke consumption of 1½ cwts. per ton of iron, excluding the coke for the bed-charge, which is about 6½ cwts., with a pressure of blast of 28 in. water, which equals 16.2 ozs. per square inch. Mr. Dalrymple, in his paper, considers as a very fair result the melting of 30 tons of iron in 5 hours in a 48 in. cupola (viz., 6 tons per hour), with 75 cwts. of coke, including bed-charge, which is 15 cwts., and a blast pressure of 21 in. water, which equals 12.2 ozs. per square inch.

Since it is the aim of every founder to work his cupola as economically as possible, speaking from an economical point of view we cannot withhold our admiration from such an ideal furnace as Mr. Bellamy seems to have brought into existance. On the other hand, we know that there are hundreds of foundries at the present day which work their cupolas under much less favourable conditions than even those stated by Mr. Dalrymple.

Let us go further, and consider from an economical standpoint the two cases mentioned above. I may call them, for the sake of simplicity, No. 1 and No. 2, and proceed to give the following comparisons:—

	No. 1. Mr. Bellamy.	No. 2. Mr. Dalrymple.
Size of cupola... ...	32 in. internal dia.	48 in. internal dia.
Melting capacity ...	10 tons per hour.	6 tons per hour.
Coke consumption ...	1½ cwts. per ton of iron.	2 cwts. per ton of iron.
,, for bed-charge.	6½ cwts.	15 cwts.
Pressure of blast ...	28in.water=16.2 ozs.	21in.water=12.2 ozs.
Class of work... ...	Gas engines.	Marine work.

Suppose both cupolas have to melt a quantity of 30 tons of iron per heat; the time of melting in No. 1 would be $\frac{30}{10} = 3$ hours, while in No. 2 it would be $\frac{30}{6} = 5$ hours. No. 1 is thus melting the same amount of iron in 3 hours, as No. 2 is melting in 5 hours. If, therefore, there are five men in charge of each of the furnaces at 6d. per hour, as No. 2 has to work 2 hours longer the extra cost per heat over that of No. 1 will be 5s., and taking the year at 300 working days (with a cast every day) we get £75 extra on the yearly cost by No. 2 method, for men's time alone.

If the blower, to produce the necessary amount of air for combustion, requires, say, 24 h.p., and the horse-power-hour be taken to cost 1d., then we arrive at 4s., or, in 300 days, £60 extra cost on running by No. 2 method.

The third and chief feature in the comparison of the two furnaces will be found in the relative consumption of coke per unit of iron melted. Taking again in both furnaces a heat of 30 tons of iron and the bed-charge of coke included in both cases, we have:—

No. 1.—1½ cwts. per ton of iron = 1½ × 30	=	45 cwts.
Plus coke for bed-charge	=	6.5 ,,
Total amount of coke for 30 tons of iron	=	51.5 cwts.
No. 2.—2 cwts. per ton of iron = 2 × 30 ,, ...	=	60 cwts.
Plus coke for bed-charge	=	15 ,,
Total amount of coke for 30 tons of iron	=	75 cwts.

The amount of coke burnt to melt 1 ton of iron is in the case of No. 1 190 lbs., and in the case of No. 2 280 lbs.

Cupola No. 1 is using 90 lbs. less coke per ton of iron melted than cupola No. 2, or 45 per cent. more coke is burned for the same amount of iron to be melted, in cupola No. 2.

Supposing the weekly tonnage of melting to be 160 tons, and taking the year at 50 actual working weeks, that is, 8,000 tons; since in cupola No. 1 in each ton of iron melted 90 lbs. of coke is saved, we get 90 × 8,000 lbs., or 320 tons, and taking the price per ton of coke at 22s., we get 320 × 22s., or £352.

The economy is, therefore, as follows:—

	Per year.
1. Five men being employed daily 2 hours less...	= £75
2. 24-H.P. blower working ,, ,, ,, ...	= £60
3. 320 tons of coke saved	= £352
Total	= £487

If we consider the work which is saved in this 320 tons of coke being brought up to the charging floor, or better, into the furnace itself, and, further, that the prime cost and maintenance of a 32-in. cupola must be considerably less than a 48-in., we may safely assume the fact that with the cupola No. 1 an annual amount of £500 is saved.

But, of course, this applies only when we assume the statements made by Mr. Bellamy to be correct. Confronted with such drastic differences, it will be well worth our while to inquire more closely into the matter; but before doing so I should like to make some general observations, namely:—

Is cupola No. 1 really capable of achieving the above-mentioned record? According to my experience as a foundryman the claim seems rather doubtful. I dare say that the melting capacity of a 32-in. cupola would be considered as very good at, say, 6 or 7 tons per hour (instead of 10 tons per hour), especially as the consumption of coke is so low and the apparatus used is only a plain cupola furnace.

It may, perhaps, be of interest to some readers to bring these two examples into comparison with some of those made with a series of cupolas by members of the American Foundrymen's Association:—

	Mr. Bellamy.	Mr. Dalrymple	Tests made by members of American Foundrymen's Association.					
	No. 1.	No. 2.	1.	2.	3.	4.	5.	6.
Internal diameter of cupola in inches...	32	48	27	32	44	54	60	72
Area of cupola in square inches	804	1,809	572	804	1,520	2,290	2,827	4,071
Weight of coke, bed-charge, lbs. ...	728	1,680	350	450	1,300	1,400	1,800	2,500
Weight of coke in succeeding charges, lbs.	84	224	90	110	175	300	350	600
Weight of iron in succeeding charges, lbs.	1,120	3,300	400	1,000	2,000	3,000	4 000	7,500
Melting ratio of succeeding charges ...	13 3	15	4.4	8.7	11.4	10	11.4	11.7
Total weight of coke in lbs.	5,768	8,064	2,000	1,250	3,075	4 800	6 600	12.700
Total weight of iron in lbs.	67,200	67,200	8,000	8,000	27,000	33,000	55 000	127,000
Grand melting ratio	11.6	8.3	4	6.4	8 8	6.9	8.3	10
Iron melted per minute in lbs.	373	224	123	130	225	300	360	567
Iron melted per square foot, in lbs. per minute.	66	18	30	23.6	21.5	19	18	20
Iron melted in tons per hour	10	6	3.25	3.5	6	8	9.6	15.2
Wind pressure in ozs. per square inch...	16.2	12.2	—	16	9.5	13	8	13.5
Ratio of tuyere area to ratio of cupola area	2.4	—	3.9	6.39	4.2	5.3	6.7	5.7
Class of work	Gas Engine.	Marine.	Job Foundry.	Gas Engine.	Stove Plate.	Pipes.		Electrical.

The above table gives some very interesting figures, but we see that there is not a single instance equal to cupola No. 1, and it shows that not even a 60-in. cupola reaches the high record of melting 10 tons of iron per hour, in spite of a higher consumption of coke.

It will, therefore, be very essential to come to the real point of this subject, and in order to do this we have to ask ourselves what are the factors to be taken into account in estimating the value of a cupola? The answers are manifold, and space will not permit us to go into all the details, but here are some of the chief points which have to be considered:—

A.
- (a). Size of cupola.
- (b). Calorific value of coke.
- (c). The brand of iron to be melted.
- (d). The kind of castings to be produced.
- (e) Melting ratio.
- (f). Arrangements for charging the cupola (weight of charges, metal and fuel.)

B.
- (g). Amount of air introduced for combustion of the fuel.
- (h). Pressure of blast.
- (i). Number, size, and arrangement of tuyeres.
- (j). Ratio of tuyere area to ratio of cupola area.

This last-named factor seems to be of the greatest importance, if we compare its figures in the foregoing table, but all the items may be considered as those which have to be invariably taken into consideration to maintain an economical working, although other points must not be neglected.

Size of Cupola.—If we refer to the table we shall see at once that the size of the cupola has a very great influence, which we best observe in the melting capacity per square foot of area per minute:—

No. 1 = 66 lbs. per square foot per minute (dia. 32 inches).
No. 2 = 18 „ „ „ („ 48 „).

This will lead us to the assumption that the melting capacity of a smaller-sized cupola is much greater. The slower rate of melting in a larger sized cupola we may ascribe to two reasons:—First, the blast in the larger cupolas, say, above 36 in. internal diameter, if not of very high pressure, is prevented, or more or less restrained, from penetrating right through to the centre; therefore, this part of the furnace is unaffected by the blast, little chance is thus given for combustion, and the area of the melting zone section is thereby reduced. Second, the greater the bulk of the brickwork, or lining of the cupola, the greater is the amount of heat taken away through radiation.

In determining the radiation of the two cupolas respectively, we may come to a fair estimate from the fact that the radiation corresponds with the rate of cooling down of the cupola after the actual melting is over and the furnace has been emptied, and from the temperature, the weight, and the specific heat of the cupola lining. (See illustration.)

FIG. 1.

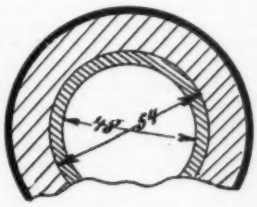


FIG. 2.

Rate of melting	=	10 tons per hour.
Coke consumption		1½ cwts. per ton of iron.
Thickness of lining affected		3 ins.
Height of lining affected ...		12 ft.
Average temperature of lining in a thickness of 3 in.		2 000° F.
Cooling down to		150° F.
Time for cooling down ...		6 hours
Specific gravity of lining ...		2 2
„ heat „ ...		0.2

Taking W (W_1 = No. 1 cupola and W_2 = No. 2), as the weight of the lining, D as the diameter of the cupola without the lining, and d as the diameter inside the lining, then—

$W_1 = \left(\frac{D^2\pi}{4} - \frac{d^2\pi}{4}\right) \times$ height $\times$ specific gravity, *i.e.*

$W_1 = (1{,}134 - 804) \times 12 \times 137 = 3{,}800$ lbs., and from this we derive W $\times$ specific heat $\times$ temp. = B.Th.U., *i.e.*, $3{,}800 \times 0.2 \ (2{,}000 - 150) = 1{,}406{,}000$ B.Th.U.

The heat given off from the lining per hour equals 234,333 B.Th.U. The amount of coke burnt per hour is 15 cwts. The heat lost per lb. of coke equals

$$\frac{234{,}333}{1{,}680} = 140 \text{ B.Th.U.}$$

If the calorific value of coke is taken at 12,000 B.Th.U., then the amount of heat lost through radiation, compared with the complete combustion of 1 lb. of coke is $\frac{140 \times 100}{12{,}000} = 1.15$ per cent.

If the same experiment is applied to cupola No. 2, with 48-in. diameter, and, as before, 12 ft. high (lining affected), then W_2 equals 5,500 lbs.

The rate of melting equals 6 tons per hour; coke consumption 2 cwts. per ton of iron, and amount of heat accumulated in the lining:—

$W_2 \times$ specific gravity $\times$ temperature = B.Th.U., *i.e.*,
$5{,}500 \times 137 \times (200 - 150) = 2{,}035{,}000$ B.Th.U.
Heat lost per lb. of coke $= \frac{2{,}035{,}000}{(12 \times 112) \times 6} = 252$ B.Th.U.
or compared with the complete combustion of 1 lb. of coke:— $\frac{252 \times 100}{12{,}000} = 2.1$ per cent.

This 2.1 per cent. represents only the heat lost in bringing the temperature of the lining from 150 degrees Fahr. to 2,000 degrees Fahr., and no reference is made to the amount of heat which is lost as sensible heat with the escaping gases at the top of the cupola, which will certainly be no little item in cupola No. 2, where 15 cwts. of coke used for the bed-charge, instead of only 6½ cwts., as in No. 1. This brings us to the conclusion that the size of the cupola must bear a certain proportion to the production of castings per year, or better, a proportion to the amount of metal to be melted per heat.

The writer knows of an instance where a new foundry was erected to produce 3,000 tons of castings per year (general machine work), which would mean, including runners, bad castings, and loss through re-melting, about 4,000 tons of metal to be melted annually, and as casting was to take place every day, each heat was of about 15 tons of iron.

Two cupolas of immense dimensions were erected, with a melting capacity of 12 tons per hour. A huge quantity of coke for the bed had to be burned for each heat, and in about an hour or an hour and a-half, when the cupola was in its highest state of efficiency, the melting process was finished. It is not surprising that that foundry, on account of this and other mismanagement, had the very short lifetime of two years.

Calorific Value of Fuel.—The calorific value of coke in case No. 1 is taken at 12,000 B.Th.U., certainly not a very good coke. In case No. 2 the calorific value is not given, but we may well assume that foundries on the North-East Coast (as in No. 2) use a coke which is by no means inferior to that used in Lancashire foundries, and, therefore, the fuel can have no influence on the fast rate of melting in No. 1. Coke of high quality may be taken at 13,000 B.Th.U.

Brand of Iron to be Melted.—Neither is the melting capacity greatly affected through this item, for the iron to be melted in the two foundries does not differ very much, although the rate of melting may be influenced in a case where hematite or Swedish pig-iron—or any other iron low in phosphorus and sulphur—is making up the chief portion of the charge. As a rule, the melting point of cast iron, as well as any other alloy, is always lower than the mean of the melting point of the individual accompanying constituents.

As the melting point of phosphorus is very low (110 degrees Fahr.) the melting point of the iron will accordingly be affected, especially where phosphorus is present in a high percentage. This we find in the case of Cleveland foundry iron, the phosphorus sometimes being as high as 1.5 per cent., and in Luxemburg and Lorraine foundry iron with phosphorus as high as 1.8 per cent. and 2 per cent. In these irons, of course, the melting point is much lower than in the case of hematite iron. With seldom more than 0.02 to 0.05 per cent. of phosphorus in the latter, the rate of melting would be reduced considerably, but as already remarked, this has little to do with the melting capacity of the two cupolas in question, since hematite was not used to any extent in either case.

Types of Castings Produced.—Cupola No. 1.—Gas engine work, cylinders (of not very thick section), bedplates, flywheels, pulleys, pipes, and general castings. *Cupola No.* 2.—Castings for marine work, cylinders of large dimensions, propellers, bedplates, general engineering castings.

No. 2 has apparently to provide an iron for a heavier type of castings than No. 1, therefore, in the former case, casting can take place at a somewhat lower temperature. Cupola No. 2 is in this respect by no means at a disadvantage, but, on the contrary, should be more favourably placed as regards melting capacity.

Arrangement of Charging the Furnaces (Weight of Charge; Metal and Fuel), and the Melting Ratio.—The differences of opinion regarding the charging of a cupola vary to the greatest extent, especially as to the arrangement and weight of the succeeding charges, compared with the size and melting capacity of the cupola. These two points deserve consideration; first, as to how the charge should be placed into the furnace; second, the proportion and weight of charges. In many cases the coke is placed mostly round the walls of the cupola, whilst the metal is charged into the centre of it, surrounded by coke. This is of no great advantage, for in the centre of the cupola there is then a straight column composed of charged metal very closely packed, and absolutely impenetrable to the ascending gases. The stream of air will not go through to the centre and then ascend, but will make a way through the more open masses of coke along the walls of the cupola. Better results will be obtained if, charge after charge, coke as well as metal is spread all over the furnace in the same thickness. It is necessary to keep the melting zone always at the same height, for if it should sink below the tuyeres, cold and bad iron will be the result. Considering the weight of charges of the two cupolas in question, we observe some rather remarkable differences:—

Cupola No. 1 (32 in. diameter); charges of iron = 10 cwts., charge of fuel = ¾ cwt.

Cupola No. 2 (48 in. diameter); charges of iron = 30 cwts., charge of fuel = 2 cwts.

Undoubtedly the weight of the charge of iron in No. 1 is more in favour of an economical melting than in No. 2; a charge which, for a 48-in. cupola, is absolutely too high. When 30 cwts. of metal is dropped into the furnace all at once, the result is that the upper portions of the cupola become cooled down to a great extent. In other words, the space which 30 cwts. of metal occupies is too large, and as there is no fuel within this space, no heat can be produced; the result will be that the succeeding charge will advance well down into the melting zone before

reaching the temperature of melting point, and metal of little uniformity will be the result.

Now we come to another, and perhaps the most important point in cupola practice, that is the proper arrangement of the tuyeres, and a sufficient supply of air for the complete combustion of the fuel. On this depends the efficiency of the cupola. In the absence of further details concerning the arrangement of tuyeres and the amount of air supply in case No. 2, we can only consider Mr. Bellamy's cupola in relation to efficiency; but before doing this, I should like to comment on Mr. Bellamy's theory, which he expresses thus:—"Since 1½ cwts. of coke is burnt per ton of iron melted, the heat efficiency of the cupola may be calculated as follows:—Amount of coke required to melt 1 lb. of iron equals 0.0705 lbs.; calorific value of coke equals 12,000 B.Th.U.; therefore the efficiency of the cupola is—

$$\frac{414 \times 100}{12{,}000 \times 0.0705} = \frac{41.400}{846} = 49 \text{ per cent.}"$$

I doubt very much whether this formula is correct, for no reference is made to the consumption of coke for the bed-charge, and, furthermore, no reference is made to the various losses of heat in detail, such as the loss of heat through incomplete combustion, and the escaping of unburnt gases (an item which may amount to from 30 to 40 per cent. of the total amount of heat lost), loss of heat through radiation, and so on. Let us assume for a moment the formula of Mr. Bellamy to be correct; then we should have for cupola No. 2 a coke consumption of 2 cwts. per ton of iron melted, the calorific value as above being

$$\frac{414 \times 100}{12{,}000 \times 0.1} = 34.7 \text{ per cent.}$$

But since the efficiency of a cupola is in direct connection with the amount of coke consumed for a certain amount of iron melted, we cannot omit to include also the amount of coke burnt as bed-charge. In doing this we obtain the following results:—

No. 1.—30 tons of metal melted with 51 cwts. coke.
1 ton „ „ 190 lbs. „
therefore $\frac{414 \times 100}{12{,}000 \times 0.085} = 40.6$ per cent.

No. 2.—30 tons of iron melted with 75 cwts. coke.
1 ton „ „ 280 lbs. „
or $\frac{414 \times 100}{12{,}000 \times 0.125} = 27.5$ per cent.

The total heat obtained from 1 lb. of coke × 49 per cent. equals 5,880 B.Th.U. Since each ton of iron melted requires 1,289,960 B.Th.U., and each pound of coke only gives off 5,880 B.Th.U. instead of 12,000 B.Th.U., then we have $\frac{1{,}128{,}960}{5{,}880}$, which equals 190 lbs. of coke, and 190 lbs. of coke per ton of iron melted corresponds to 40.6, and not 49 per cent.

To make the foregoing examples more clear, let us assume the combustion to be complete (all carbon burnt to CO_2), and the fuel to be pure carbon and not coke, then we arrive at the following:—

Amount of heat required to melt 1 lb. of iron = 504 B.Th.U.

Amount of heat obtained in burning 1 lb. of carbon to CO_2 = 14,500 B.Th.U.

Amount of pure carbon required to melt 1 ton of iron

$$= \frac{1{,}128{,}960}{14{,}500} = 77.85 \text{ lbs.}$$

Amount of pure carbon required to melt 1 lb. of iron

$$= \frac{77.85}{2{,}240} = 0.034 \text{ lbs.}$$

which gives $\frac{504 \times 100}{14{,}500 \times 0.034} =$ say 100 per cent.

In practice, however, the fuel is not pure carbon, but coke, and in this case with a value of 12,000 B.Th.U.; therefore $\frac{12{,}000 \times 100}{14{,}500} = 82$ per cent.

Unfortunately, Mr. Bellamy does not give an analysis of the escaping gases; the amount of air introduced into the cupola can best be obtained from the composition of the gases with regard to the amount of carbon burnt in a certain unit of time. Almost the whole of the carbon burnt in the fuel is found in the escaping gases again, except a very small amount that combines with the descending drops of fluid metal. The carbon in the gases becomes, by complete combustion, CO_2, and by incomplete combustion, CO. The amount of oxygen in these two gases (CO_2 and CO) is obtained from the blast. An analysis of the escaping gases would at once indicate whether the necessary amount of air was delivered or not.

On the other hand, it is quite possible to introduce too much air into the cupola, and, curious to say, this will generally be the case where the area of the tuyeres in comparison with the area of the melting zone of the cupola is too small, and the blast is of a very high pressure. As a result, combustion is confined to a small space near the tuyere openings, and the severe action of the high pressure of the blast will bring about an unnecessary cooling down in the melting zone, and, perhaps, lead to frequent choking of the tuyeres; further, if the tuyere area is too small, and the pressure too high, the latter will give the blast a direct proportional increase of velocity, so this greater velocity will prevent the ascending air stream from coming in proper contact with all the surfaces of the coke-pieces, and the blast will arrive at the stack of the cupola without having given up all its oxygen to the carbon of the coke; incomplete combustion will be the result, in spite of the large quantity of air introduced.

If too much air is introduced, free oxygen will be found in the gases, which will result in the oxidation of silicon and manganese, and more probably ferro oxide, and no constituent in cast iron can be more detrimental than FeO. The amount of air necessary for complete combustion may be found first through the amount of oxygen and also through the amount of nitrogen in the gases. For ordinary cupola practice the atmospheric air may roughly be taken at 23 parts by weight of oxygen and 77 of nitrogen. After determining the amount of air required for the complete combustion of 1 lb. of carbon we may obtain the amount of air required for 1 lb. of coke (coke in our case equals 12,000 B.Th.U.) by multiplying with

$$\frac{12{,}000}{14{,}000} = 0.82.$$

Determination of Air by the Amount of Oxygen in the Gases.—For complete combustion the gases must contain carbonic acid (CO_2) 23 per cent. (no CO or O), and N (nitrogen) 77 per cent. Since 1 lb. of CO_2 contains $\frac{12}{14} = \frac{3}{11}$ lb. of carbon, and 1 lb. of CO_2 contains $\frac{32}{44} = \frac{8}{11}$ lb. of oxygen, the escaping gases will contain 23 per cent. CO_2. Since $\frac{3}{11} \times 23$ equals 6.27 lbs. of carbon in 100 lbs. of gases, and $\frac{8}{11} \times 23 = 16.73$ lbs. of oxygen in 100 lbs. of gases, 1 lb. of carbon will require $\frac{16.73}{6.27} =$ 2.67 lbs. of oxygen. This 2.67 lbs. of oxygen equals $\frac{100}{23} \times 2.76 = 11.60$ or say 12 lbs. of air. For each 1 lb. of carbon burnt in the fuel, 12 × 13.14 = say, 160 cubic feet of air are required. Or, in the case of coke, 160 × 0.82 = 132 cubic feet of air.

Determination of Air by the amount of Nitrogen in the Gases.—In 100 lbs. of gases, as stated above, there are 6.27 lbs. of carbon (complete combustion), but 100 lbs. of gases contain 77 lbs. of nitrogen. Therefore, 1 lb. of carbon $= \frac{100}{6.27} = 16$ lbs. of air. Taking nitrogen as basis instead of oxygen we have $16 \times 13.14 = 200$ cubic feet of air, instead of 160 cubic feet. Or, in the case of coke, $200 \times 0.82 = 165$ cubic feet instead of 132 cubic feet. These differences may be explained by the fact that the first method is not exactly correct, because a small amount of oxygen is lost through oxidation with silicon, manganese, and iron, and cannot therefore be found again in the escaping gases. The amount of air required per pound of coke with a calorific value of 12,000 B.Th.U. (for the combustion to be complete) is 165 cubic feet.

If we take cupola No. 1, into which is delivered 36,000 cubic feet per ton of iron, or as Mr. Bellamy says, 168 lbs. of coke, then we have $168 \times 165 = 27{,}700$ cubic feet of air introduced, or $36{,}000 - 27{,}700 = 8{,}300$ cubic feet more per ton of iron melted than is necessary for complete combustion. It is, therefore, questionable whether such an immense amount as 36,000 cubic feet is really required, and if an analysis were made of the escaping gases, we certainly should find a fair amount of free oxygen, an element which in this case is of no advantage.

Having considered now these points on which depends the economical working of a cupola, we come to the following conclusions:—That No. 1 cupola has the advantage of a faster rate of melting on account of a large and sufficient amount of air being introduced through the largest possible tuyere area. Further, the proportions of the charges in weight are kept within the limits, and in connection with these two items a smaller furnace with less radiation of heat, and certainly with a much less consumption of coke for bed-charges, as well as for succeeding charges for the same amount of iron to be melted, will do the same work or will be more economical than a much larger furnace supplied with an insufficient amount of air, unfavourably selected charges, and a much higher consumption of coke.

In conclusion, I may say that practically no two cupolas work exactly at the same rate, or with the same economy, but in a case where the differences are so great that in producing the same amount of molten metal per year one furnace can save, say, £500 a year, that furnace most certainly deserves consideration.

A Substitute for Ferro-Silicon.

Ferro-silicon has attained a place of importance in the steel industry that is probably unrivalled by any such alloy, unless it be ferro-manganese. The development of the use of ferro-silicon has been very marked during the last few years, this being due to the perfection of the electric furnace, which permitted the production of an alloy containing a high percentage of silicon and low percentages of carbon and other impurities. Formerly the only means of production was the blast furnace, but this method presents many difficulties, and there cannot be obtained such a high percentage of silicon as by the use of the electric furnace. While ferro-silicon has proved to be of particular value to the steel trade, however, its use is attended by very grave dangers. The high-grade alloy obtainable from the electric furnace, if allowed to come into contact with water or a moist atmosphere, gives off large volumes of poisonous and explosive gases, and these undesirable properties of the alloy have been made unmistakably evident by the occurrence of a number of serious accidents. One recent example, which we reported at the time, was the accident on board the s.s. "Ashton," five persons being poisoned by the gaseous emanations of a quantity of ferro-silicon which was being conveyed. This emphatic demonstration of the dangerous nature of the material has caused many shipping companies to refuse to carry it in future; while, on the other hand, suggestions have been offered as to substitutes for ferro-silicon which do not involve the same risks, carbide of silicon being suggested as one alternative material.

Another substitute for ferro-silicon has been found in silico-manganese, which does not give off poisonous or explosive gases. This is a compound alloy of silicon, manganese, and iron, containing only traces of carbon, phosphorus, and other impurities. It is a product of the electric furnace, from the direct smelting of a highly silicious manganese ore. Silico-manganese can be used with advantage in all processes of steel manufacture where ferro-silicon and ferro-manganese have been employed. It is a powerful deoxidant and remover of occluded gases and oxides from steel, and is used to introduce either silicon or manganese into steel, or it may be used in cases where both elements are desired to be introduced.

In the open-hearth acid process the alloy may be added to the bath in the furnace shortly before tapping, or it may be added to the metal in the ladle with equally good results. In the former case the metal should be worked to the desired carbon content, and the slag should be adjusted until it is in a well wrought clean condition, and of medium thickness (depending upon the class of material being made). The correct calculated weight of alloy to give desired amount of silicon and manganese in the finished material, broken in moderately small pieces, should be added to the bath, in frequent small quantities, three or four minutes before opening the tap hole. The bath should be well rubbed up before tapping. In the event of a higher manganese being desired in the finished steel than can be added without raising the silicon to too great an extent, or where the silicon has to be kept below certain specified limits, sufficient ferro-manganese can be added to raise the manganese in the steel to the desired point. The latter may be added either to the bath or the ladle, with equally good results.

In the second case, viz., adding the alloy to the ladle, the remarks about the condition of the carbon and slag apply as in the case of addition to the bath. The crushed and preferably heated alloy should be dropped in frequent small portions on to the stream of metal as it leaves the shoot. Under these conditions the silicon and manganese are thoroughly and evenly distributed throughout the whole mass. If the additions are made all at once, or splashed haphazard into the ladle, there is danger that complete mixing will not take place; the slag oxides and some silicate of manganese is formed which may not rise to the top, but get occluded in the metal, with the result that hard patches and "ghost" mark-

ings will appear in the finished products. In cases where higher manganese is required it is well to have the required amount of ferro-manganese mixed with the silico-manganese, both then being added together.

Silico-manganese is manufactured in several grades, varying in the respective percentages of silicon and manganese, and the grade most suitable for the work in hand should be selected. It is made containing from 20 to 40 per cent. of silicon, and from 55 to 75 per cent. of manganese. The lowest percentage of silicon is the grade most suitable for plates, structural material, and soft steel in general. The highest silicon grade is most suitable for castings.

In the open-hearth basic process, owing to the readiness with which phosphorus goes back from the slag to the metal, the silico-manganese should always be added in the ladle. In this process more of the silicon is oxidised and sent to the slag than in the acid furnace, consequently a greater amount of the alloy may be added without unduly increasing the silicon content of the finished steel, and the whole of the manganese required in the steel up to about 0.7 per cent. to 0.8 per cent. may be introduced by means of the silico-manganese alone. Silico-manganese is a much more valuable agent in the basic than it is in the acid process, especially where the material is worked down to very low carbon and phosphorus content. Steel of this description is required to carry considerably more heat, and is very frequently inclined to be "wild." It is said that silico-manganese has a remarkable action on such steel, causing it to be quite quiet in large moulds and stand without plating, even when the metal is wild when tapped. This, of course, reduces the amount of waste on the top ends of the ingots. In the basic Bessemer process the additions of the alloy should be made to the ladle, as in the open-hearth basic process.

It is a well established fact that the addition of ferro-manganese or spiegeleisen liberates large volumes of carbonic-oxide gas, which causes a violent agitation of the metal, and which, apart from any direct reducing action, causes a return of the phosphorus to the metal. The use of silico-manganese, it is claimed, prevents this undesirable return, and it also does away with the use of ferro-silicon. The advantages of having only one addition to make instead of two will be readily appreciated in basic Bessemer works.

Among the advantages claimed for silico-manganese are that it is very economical in use, the silicon protecting the manganese from oxidation and the loss of the latter being, therefore, much less than when ferro-manganese only is used; further, it contains practically no carbon, and is therefore a most valuable means of adding silicon and manganese to steel which has to be kept very low in carbon.

Silico-manganese is perfectly harmless in use, and may be stored in bulk quite safely. Experiments have proved conclusively that ferro-silicon gives off explosive and poisonous gases, but, according to experiments conducted by Mr. A. Campion, under similar conditions, neither phosphoretted nor arseniuretted hydrogen is liberated from silico-manganese. These experiments were similar to those conducted by the Laboratories of the Royal Institute of Public Health, the report concerning which we published in our issue of last month, and they confirmed the claim that silico-manganese is a safe material both as regards transit and storage.

This alloy has been introduced and placed on the market by Messrs. Roberts, Evans, & Woodhead, African Chambers, Liverpool. The following is an analysis of samples of the alloy taken from 6 casks and 16 cases:—Manganese, 69.06 per cent.; silicon, 25.66 per cent.; iron, 4.65 per cent.; aluminium, nil; copper, nil; nickel, nil; calcium, nil; carbon, 0.49 per cent.; sulphur, 0.029 per cent.; phosphorus, 0.054 per cent.

THE NATIONAL PHYSICAL LABORATORY.—On March 19 the National Physical Laboratory, Bushy House, Teddington, was thrown open to inspection to a number of technical journalists, engineers, metallurgists, and others interested, on the invitation of Sir Archibald Geikie, the chairman. The work of the Department of Metallurgy and Metallurgical Chemistry includes metallurgical research and investigatory testing involving the application of the microscope and pyrometer to the study of metals. The investigatory testing deals chiefly with cases of failure occurring in practice, which are referred to the Laboratory and dealt with jointly by the Metallurgy and Engineering Departments. The researches of the Department are directed to the study of important groups of alloys (chiefly in connection with the Alloys Research Committee of the Institution of Mechanical Engineers) and to the elucidation of the structure and constitution of metals and alloys generally. For the preparation of alloys on a larger scale a small foundry is provided with appliances capable of dealing with 60 lbs. of molten bronzes or iron. The mechnical tests on alloys thus prepared are carried out in the Engineering Department.

IT is reported that the Spanish Shipbuilding Company, with which is associated the firm of Messrs. Vickers, Sons & Maxim, has decided to accept the modifications proposed by the Spanish Government in the tenders submitted for the construction of a Spanish naval squadron. The syndicate is composed of Messrs. Armstrong, Whitworth & Company, Elswick; Messrs. Vickers, Sons & Maxim, Barrow; Messrs. John Brown & Company, Clydebank and Sheffield; Messrs. Thorneycroft & Company, Southampton; and the Parsons Marine Turbine Company, Wallsend. The vessels will be built at Ferrol and Cartagena, and will comprise three ironclads, three destroyers, 24 torpedo boats, and four gunboats.

IMPORTANT changes in the directorate and management of the Palmer Shipbuilding and Iron Company, Limited, are officially announced. These changes include the election of Sir Christopher Furness as deputy-charman, the election of Sir Archibald Douglas, K.C.B., on the directorate, and of Mr. Malcolm Dillon as a local director; while the general management has been vested in Mr. A. B. Gowan, of Glasgow. Sir Charles McLaren is remaining chairman of the company, and another admiral, with sea-going experience up to a recent date, is to be added. A further addition has been made by the appointment of Mr. Gerald Talbot, who will represent the company abroad.

THE announcement in the recently-issued Navy Estimates that provision is made for the erection in Sheffield of a testing-house and workshop for the use of the Government inspectors of steel has excited some amount of interest. A testing plant for the purpose named has, however, been in existence for about 20 years. Owing to the growth of the work in recent years, the inspectors now require more accommodation, and it has been decided to erect new and larger premises, suitably designed and situated nearer to the steel works in which most of the Government requirements are produced.

AT the second annual meeting of the Swedish Chamber of Commerce in London, held at the Cannon Street, Hotel, on March 19, it was stated that arrangements were being made for the holding of a Swedish Industrial and Agricultural Exhibition in London in 1911.

New Charging Appliances for Cupolas.*

In selecting the method of charging the cupola furnace in improved plants designed for a large output, there are two systems to chose from, one in which the pig and scrap are broken down outside, and raised to the charging floor, to be classified and mixed later on; and the second in which the whole of the iron is hoisted to the floor, treated there in a breaker, and mixed at once for charging. This second method is preferable, as the material does not require so much handling, and there is less room for error in classifying the metal. In both cases the cupola can be charged by the aid of hopper wagons, discharging at the side, as shown in Fig. 1. The charging floor being level and of hard material, no rails are needed. The weighing machine is mounted with its platform on a level with the floor, and is preferably arranged so that the travelling weight on the lever arm cannot be moved beyond a stop previously adjusted by the foreman, the recording apparatus being enclosed and inaccessible to unauthorised persons. The coke tippler is preferably arranged overhead (Fig. 1), so that the coke can be discharged into a heap, instead of having to be piled up with the shovel.

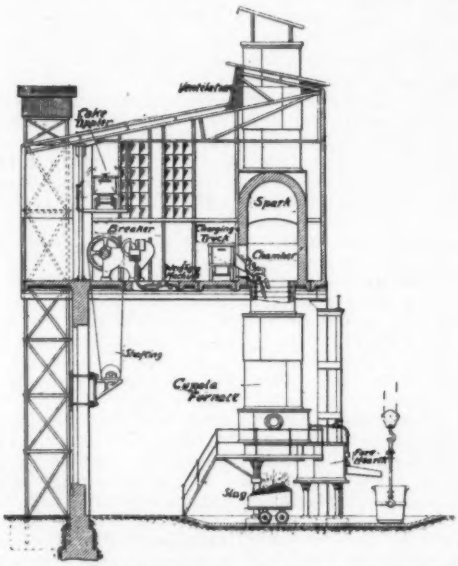


FIG. 1.—ARRANGEMENT FOR CUPOLA CHARGING.

Though the arrangement illustrated in Fig. 1 constitutes an advance on the old methods of charging by hand, it has the defect that the supervision of the charging process is necessarily intermittent, and entails ascending to the charging platform, thus taking up more time than can well be spared. Hence, the success of the charging is too greatly dependent on the care and reliability of the workmen; and the only way in which this can be satisfactorily replaced is by the use of automatic charging devices. In these devices, however, the employment of the ordinary type of elevator is a source of imperfection. A better type is employed in some American works, the loaded trucks being tilted in front of the charging hole by means of a pneumatic hoist; but here again also defects arise from the use of such complicated mechanism. The best method of all is the inclined hoist, with separate hoisting bins, by means of which the charge is hoisted and tipped into the furnace at one operation, thus dispensing with any intermediate handling and all work on the charging platform. An appliance of this kind (Fig. 2) has been devised by Mr. L. Keyling, and put on the market by Mr. E. Becker, of Reinickendorf, Berlin. The hoist is operated by a motor, and the skips, which hold 12 cwts. of metal, are raised to a height of 20 ft. at a velocity of nearly 50 ft. per minute. The skip rests on a weighing machine on the ground floor, so that it can be filled and weighed without trouble, and when this has been done, a simple pull on the check cord starts it on its journey to the charging mouth of the furnace, where it engages with a projecting hook and is tipped. An automatic stop motion throws the motor out of operation at each end of the trip. A guard of wire netting affords protection against any pieces of metal or coke that may be accidentally thrown out of the skip. The platform is comparatively small, being provided for the accommodation of a small reserve of metal and coke, in the event of the hoist getting out of order. A belt can be used for driving, in place of a motor, if preferred.

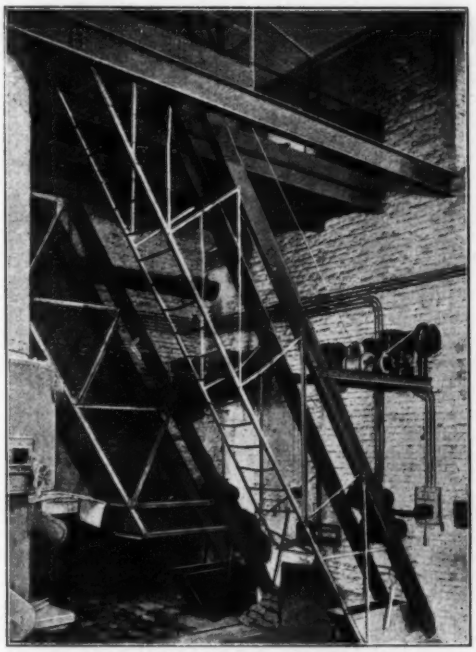


FIG. 2.—INCLINED HOIST FOR CHARGING CUPOLAS.

The higher cost of the automatic charging apparatus is compensated by the saving in labour and the abolition of the usual hoist; while if two cupolas are used, one motor will serve both hoists. Another advantage is the diminished risk of accident to the workmen, including the danger of carbon monoxide poisoning.

* T. Ehrhardt in "Stahl und Eisen."

Dry v. Wet Coke for the Cupola.*

In a Swiss foundry, using fresh Westphalian coke (ash content, 7.5 per cent.) for the cupolas, a store of two-year-old coke containing only 0.5 to 0.8 per cent. of water was occasionally drawn upon for charging. Examination of the furnace gases, however, showed a higher percentage of carbon-dioxide from the dry coke, whereas, by wetting it, or using fresh coke, a more economical result was obtained. A comparison was instituted between the results of charging with the dry coke, fresh coke with 5 to 8 per cent. of moisture, and wet coke with an average of 10 per cent. of water (occasionally rising to as much as 18 per cent.). The quantity of coke used, calculated to 100 parts of iron, was 7.4 to 8.3, 7.5 to 8.2, and 6.9 to 7.8 parts respectively, the actual consumption being, therefore, approximately the same in each case; but the composition of the furnace gas differed considerably. For example, 100 volumes of gas from the dry coke contained 10.7 volumes of carbon-monoxide and only 13.3 volumes of carbon-dioxide, whilst in the case of the fresh and wet coke respectively the proportions were 7.2 or 8.7 to 16, and 5 or 6 to 17.3 or 17.7 volumes.

To account for the cause of this difference, it must be remembered that smelting in the cupola is a neutral process, the sole purpose of which is not to effect any oxidation or reduction of the charge, but to melt the pig-iron by heating it with the coke. It is desirable, on the one hand, that the furnace gases should escape at as low a temperature as possible, their heat having been utilised as completely as practicable in the cupola itself. The transference of heat from the ascending gases to the descending charge depends on the duration of contact between the two; and, therefore, it is advisable that the cupola should be adequately charged, since, otherwise, the heat will not be utilised economically. On the other hand, when the column of material in the cupola is high, the combustion of the coke is incomplete, ceasing at the carbon-dioxide stage, provided the volume of air blown into the cupola is no greater than is sufficient to fully oxidise the carbon in a charge of smaller vertical dimensions, because complete combustion to carbon-dioxide requires twice as much oxygen as oxidation to the monoxide stage. It is important for the economical working of the cupola that the oxidation should be as complete as possible, in order that the heat may be properly utilised; and where complete combustion cannot be obtained, one must be satisfied to secure a high ratio of carbon-dioxide to monoxide.

Since we are concerned only with the composition of the gas above the charge, the old dispute as to whether carbon-monoxide is formed first, and then oxidised to dioxide, or whether the dioxide is formed straight away, may be left out of consideration. The manager of the Swiss foundry in question reported that the damp or wet coke burned only in the stratum directly opposite the tuyeres, whereas the dry coke became incandescent for a considerable height above, his idea being that the ascending carbon-dioxide was thus afforded an increased opportunity of taking up carbon. This idea brings up for consideration the phenomenon of the reduction of carbon-dioxide by solid carbon, with formation of carbon-monoxide, the latter then escaping from the cupola without having contributed to the heating of the charge. Moreover, the reduction to monoxide absorbs heat, and consequently any lowering of the ratio CO_2/CO by such process of reduction entails a considerable increase in the consumption of fuel. The combustion of 1 lb. of carbon to dioxide furnishes 36,360 heat units, whereas, only 25,245 units are yielded by combustion of the same amount of carbon in the state of monoxide, the difference, 11,115 units, having been liberated during the conversion of the carbon into dioxide. Now, the formation of the monoxide by reduction of the dioxide absorbs the same amount of heat as is subsequently disengaged again when the monoxide is burned; but this subsequent disengagement of heat taking place above the level of the charge, is wasted, so far as heating the latter is concerned. If in burning 1 lb. of carbon at the tuyeres of the cupola 70 per cent. were converted into dioxide and 30 per cent. into monoxide, about 28,800 heat units would be produced; consequently, the loss of heat sustained by the interruption of the combustion of 1 lb. of coke at the monoxide stage (*i.e.*, reduction of the dioxide to monoxide), is 14,130 + 28,800 = 42,930 units. This amount of heat must be made good by the consumption of a corresponding extra amount of coke.

The researches of Naumann and Pister have shown that the reduction of carbon-dioxide to carbon-monoxide, continues down to a temperature of about 550 degrees C., the amount of monoxide formed being greater in proportion as the temperature is higher; and Boudouard recently found that the reaction ceases at 445 degrees C. These latter results, however, were obtained by prolonged exposure, whereas, owing to the velocity with which the gas ascends in the cupola, it is improbable that any change in the composition of the gas will ensue after it has reached a level at which the temperature is below 550 to 600 degrees C., and the reaction will therefore be practically confined to the incandescent zone. In the interests of economical working, it is, therefore, desirable to restrict the zone in which this reaction can occur to the smallest dimensions; the longer the fuel remains cold, and the more rapidly the ascending gas is cooled, the better. The simplest method of attaining this end would be to bring the gas into contact with a sufficiently large quantity of material (pig-iron and lime) in the cupola to cool it down quickly; but a limit is placed on this by the necessary intermingling of the fuel required for melting and superheating the iron and slag.

Although the results of the gas analysis and the observations of the manager lead to the supposition, they do not afford any proof, that the presence of moisture in the coke really causes the cooling of the gas in the cupola. The only published expression of opinion on the use of damp coke in cupola work is one by Gienanth, who controverts the assumption that such coke parts with its moisture in an explosive manner on reaching the zone of incandescence. This, he states, is impossible, the whole of the moisture being necessarily expelled, owing to the temperature in the shaft, very soon after the coke has been placed in the cupola. On the other hand, he considers it advisable to damp the coke, in order that the moisture, by absorbing heat during evaporation, may protect the carbon from premature combustion and leave as large a quantity of this substance as possible to reach the actual zone of combustion.

Now, the amount of heat necessary to raise 1 lb. of water from zero C to steam at 100 degrees C.

* C. Geiger in "Stahl und Eisen."

is 288 units, an additional 0.225 unit being required to superheat the steam 1 degree C. Assuming the initial temperature of the coke to be 10 degrees C., the heat required to raise 1 lb. of water in the charge of coke to 200 degrees C. will be 306 units. Hence the deduction that must be made from the total heating power of the coke containing 10 per cent of moisture, is only 30.6 units in the least favourable circumstances. If the coke contain 80 per cent. of carbon, and 70 per cent. of this be converted into carbon-dioxide, and 30 per cent. into the monoxide, the total heat evolved per lb. of coke will be 2,303.1 — 30.6 = 2,272.5 units. This means that the charge of coke must be increased by 1.3 per cent.

With dry coke containing only 0.5 per cent. of water and 89 per cent. of carbon, under similar conditions, the amount of heat produced is 2,362 units. The analysis of the furnace gases, however, shows that on the average one-eighth of the carbon-dioxide produced is reduced to carbon-monoxide, and therefore the heating power of about 0.04 lb. of coke is wasted, so that the actual consumption of coke must be increased by 9 per cent.

These theoretical considerations explain the possibility of obtaining more economical results in the cupola with wet coke than with dry fuel, though, of course, it must not be forgotten that a modification in the method of working the cupola might perhaps give better results with the dry coke.

The Making of a Mould Direct from a Drawing.

By T. Cowden.

There is extensive scope for the system of making a mould direct from a drawing with the aid of a few boards. This method presents many advantages and saves money, as very little work is required of the pattern-maker; also the cost of the wood which would have been necessary for a solid pattern goes to swell the profits of the business. There are a great many moulds which can be easily made in this way, including, amongst others, pistons, piston-rings, cylinder covers, liners, some plain cylinders themselves, and many others, only a very small percentage of pattern-making being required.

Figs. 1 and 2 show the drawings necessary for the moulding of the casting, herewith described, which

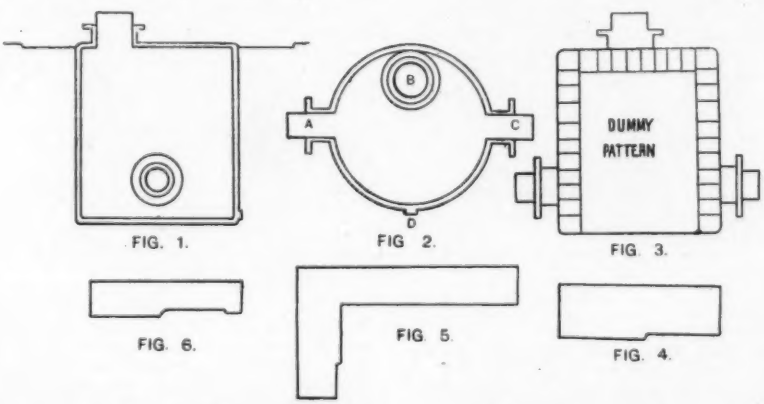


FIG. 1. FIG 2. FIG. 3.

FIG. 6. FIG. 5 FIG. 4.

may be either made in sand or loam. I will give a brief outline of the loam method first. The usual bottom plate, socket, and spindle, also the arm for fixing the board on to, will be required. The work required to be done by pattern-makers will be as follows:—Three strickle boards and whole pattern for branches marked A, B, C, small boss D, as shown in Fig. 2, and drawings showing elevation and sectional plan respectively, being required. The first board used will be the one (Fig. 4), which sweeps the bottom part of the mould. This one is taken off and the board (Fig. 5) fixed on; the outside of the mould is built up and finished to the correct size. It may be noted that this board will do for the main core of the casting also. A top plate with dabbers will now be required for the top part of the mould; this is swept up in the usual manner and finished, the board (Fig. 6) being used. The core meantime will have been made by the core makers, the board (Fig. 5) for the central portion of the mould being used. A straight board will also be required for the forming of the branch cores, which can be run up with straw ropes on a suitable bar. The mould is now ready for the stove, and when dry is taken out and closed ready for casting. This casting can also be made in sand by using the same boards, only the one (Fig. 5) will not be required; the difference will be added on to the length of that one. The socket and spindle will be fixed on to the drag part of the moulding box, the strickle board (Fig. 4) being used as in the loam method. This is taken off and board (Fig. 5) fixed up as if you were going to build the core, only it is fixed for the mould size. A dummy pattern is now built up of loam and brick, as shown in Fig. 3 in the sketches, to which the branches and boss may be fixed, the moulding may now be proceeded with in the usual manner.

It will be seen from this rough outline of procedure that a knowledge of geometry is essential on the part of the moulder, as he has to work from the drawing supplied, and has also to draw off and place in their correct places the solid parts of the pattern in both methods.

Monel Metal.*

By David H. Browne.

During the last three years the International Nickel Company has been investigating the physical and chemical properties of a new alloy of nickel and copper which is now coming into commercial use under the name of Monel metal. This alloy has at the present time been put to so many uses and possesses such remarkable properties that a brief description of these may be of general interest.

Monel metal consists primarily of nickel and copper in the proportion of three parts of nickel to one part of copper, this being the natural proportion in which these metals exist in the largest deposits of nickel ore in the Sudbury district of Canada. Throughout its entire manufacture this alloy acts as a single metal, and while the proof is still incomplete, evidence seems to show that in these proportions nickel and copper have a remarkable affinity for each other.

Like steel, this alloy absorbs carbon, and, like steel, its physical properties are profoundly influenced not only by the percentages of carbon, silicon, etc., but by the heat treatment it receives. A standard analysis of Monel metal is as follows :— Nickel, 68 to 72 per cent.; iron, 0.5 to 1.5 per cent.; sulphur, 0.014 per cent.; carbon, 0.073 to 0.15 per cent.; copper to balance.

This alloy is silver-white and takes a brilliant finish, which it retains indefinitely. On prolonged exposure the surface assumes a grayish cast, which may be easily removed with a polishing cloth. In the rolled sheets, the surface assumes on heating a coating of oxide which has great resistance to acids. Samples of the rolled metal showed no loss in 56 days' test in pumping 40 degrees sulphuric acid. A special pickle has to be used to remove the oxide coat for articles destined to be polished, but for purposes where resistance to acid is required, the oxide coating is allowed to remain.

Monel metal melts at 1,350 degrees C. It can be rolled perfectly from 900 degrees to 1,200 degrees C., and its annealing temperature is above 875 degrees C. It can be finished hard or soft, like sheet copper. Its specific gravity, as cast, is from 8.86 to 8.87, and when rolled from 8.94 to 8.95. The cast Monel metal is at present made in two grades, with the following qualities :—

	Grade C.	Grade D.
Tensile strength...	70,000	85 000
Elastic limit	27,000	40,000
	Per cent.	Per cent.
Elongation in 2 inches ...	30	25
Reduction of area	35	25

These compare very favourably with the Government specifications for carbon-steel castings, viz. :—

	Hard.	Medium.	Soft.
Tensile strength ...	85 000	70,000	60 000
Elastic limit... ...	38,250	31,000	27,000
	Per cent.	Per cent.	Per cent.
Elongation	15	18	22
Contraction	20	25	30

In the rolled and annealed condition Monel metal is stronger than nickel steel, as the following tests will show :—

	Monel metal 1-in. rods. As rolled.	Average tests. Rolled, annealed and cold drawn.
Tensile strength ...	100,000	110,000
Elastic limit... ...	50,000	80,000
	Per cent.	Per cent.
Elongation 2 inches	30	25
Reduction of area...	50	50

For comparison the specifications of steel forgings are given below :—

	Carbon steel. Annealed.	Carbon steel. Oil tempered.	Nickel steel. Annealed.	Nickel steel. Oil tempered.
Tensile strength ...	80,000	90 000	80,000	95,000
Elastic limit	40,000	55,000	50,000	65,000
	Per cent.	Per cent.	Per cent.	Per cent.
Elongation 2 inches	22	20	25	21
Reduction of area...	35	45	45	50

Some tests of ½-in. rolled plates furnish an interesting comparison with soft steel and copper.

	Monel metal.	Soft steel.	Copper.
Tensile strength ...	90,000	60,000	34,000
Elastic limit... ...	45,000	30,000	18,000
	Per cent.	Per cent.	Per cent.
Elongation 2 inches	30	35	52
Reduction of area...	60	35	57

We have here a metal possessing about 25 per cent. greater tensile strength and 50 per cent. greater elastic limit than the best rolled steel, with the additional quality of incorrodibility. The mechanical possibilities open to such an alloy are endless.

During the last year some 300,000 sq. ft. of Monel metal sheets were used to roof the Pennsylvania terminal station in New York City. The manufacturers, who have tested this material for roofing, state that they find it as easily worked as copper. The sheets are silvery-white, exceedingly flexible and malleable, and are handled in exactly the same way as sheet copper.

The rolled metal has been drawn into wire of all sizes down to 0.004 in. This latter is as soft and pliable as a silk thread. In the form of wire exhaustive tests have been made of the metal for purposes where its incorrodibility makes it especially effective. In small articles, such as tacks, bolts, screws, angle braces, and such stamped work as door and window trimmings, hinges, gas and electric fittings, and other small articles, it is said to be rapidly finding its way into the market.

What is claimed to be one of the most satisfactory uses of Monel metal is in seamless tubes for condensers and boilers for automobiles and motor boats. The metal draws perfectly into a smooth tube, and its high elastic limit and tensile strength, combined with its incorrodibility, are of especial value in light machinery. The largest casting so far made was a solid hub and propeller for a steamer. This casting was 9 ft. 6 in. in diameter and weighed 6,500 lbs. It has given perfect satisfaction. Larger castings can be made, and as the material is much stronger than manganese bronze or Tobin bronze, it is eminently suitable for any purpose to which these have hertofore been applied. Some of the physical constants of the metal, its electrical qualities, the effect of varying amounts of carbon, silicon, copper and iron, yet remain to be worked out.

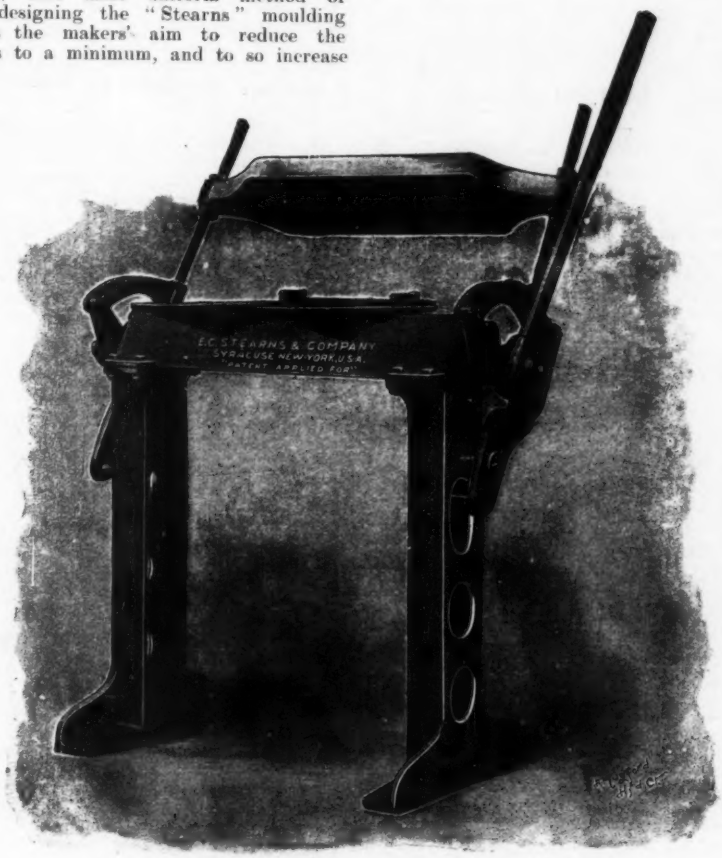
* "Electrochemical and Metallurgical Industry."

MR. ALFRED WISEMAN, Glover Street, Birmingham, has been appointed sole licensee for the Midland Counties, for the new Ferrofix brazing process for brazing cast-iron. Mr. Wiseman's installation comprises a high-pressure Roots' blower, which is driven by belt from line shafting. Gas is taken from the town supply for the 30 large Bunsen torches, each giving an inch dia. flame. These are so arranged for dealing with every description of work up to heaviest castings.

The Stearns Moulding Machine.

A simple little machine, especially adapted for plain small repetition work, is illustrated herewith. For nearly all work that is made on the bench in snap flasks the so-called "squeezer" type of machine, which simply presses the sand and more effectively takes the place of hand ramming, affords the easiest, most economical, and most uniform method of moulding. In designing the "Stearns" moulding machine, it was the makers' aim to reduce the number of parts to a minimum, and to so increase the leverage that the least exertion should be required to operate it. By its use the moulds are pressed uniformly, whether the operator is experienced or not. The machine itself controls the evenness of the pressure. It is claimed that the average moulder with a "Stearns" machine will put up from 25 to 33 per cent. more moulds per day, with less exertion than he can with rammers. The simplicity and ease of operation is one of the particular features of the machine. It possesses exceptional leverage and requires a shorter movement of the lever to perform the work. One hand only is needed to press the mould, and the operator is able to bear his full weight, if required, on the lever.

It will be observed that the table is made in the shape of a pyramid or inverted "V," on which the sand will not remain but will slide off; therefore, the machine will not become clogged with sand. All of the working parts are under the apex of the inverted "V," consequently the sand does not affect them.



THE STEARNS MOULDING MACHINE.

The parts are made interchangeable, and the machine is made in two sizes only, the size in most general use being made to take any flask up to and including 18 by 24 in., and 10 in. deep.

For larger work the makers produce a heavier machine, taking flasks up to and including 18 by 30 in. and 10 in. deep. Its general dimensions are same as the regular size machine except that it has an extreme width of 44 in. over all, and an extreme width between side rods of 36 in.

Some makers of moulding machines recommend the use of sprue cutters, but the makers of this machine suggest a sprue with a hole in it to set over the draw-pin in the pattern, a hole being cut in the presser board sufficiently large to admit the head of

the sprue. Care should be used to see that the sprue is not so long that it will strike the presser head of the machine.

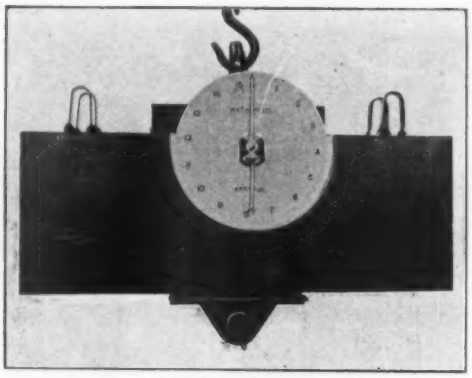
Flasks of any ordinary type, either wood, solid iron, or snap flasks, may be used on the "Stearns" machine. The best results, however, are obtained from snap flasks properly provided with pins on the inside to regulate the depth of pressure on the sand. Bottom boards should be at least 1 in. shorter and narrower than the inside of the flask, thus providing a clearance of $\frac{1}{8}$ in. all round. This applies to the presser board as well.

The makers are Messrs. E. C. Stearns & Company, New York, U.S.A., for whom Messrs. Ludw. Loewe & Company, Limited, London, E.C., are the agents in Great Britain.

Weighing Molten Metal.

In the economy of the foundry the question of estimating the amount of molten metal in the ladle often arises. Hitherto it has been the custom to simply judge the quantity required, with the result that now and then trouble has arisen from not having enough metal, or from having too much.

Owing to the heat involved in the operation of tapping the cupola, the ordinary crane weighing-machine would be rendered practically useless. In



APPLIANCE FOR WEIGHING MOLTEN METAL IN THE FOUNDRY.

order to overcome this difficulty, a special machine has been designed to give the exact weight of the metal contained in the ladle without the heat in any way affecting the weighing mechanism. This has been accomplished by the addition of a special protector or covering, consisting of a non-conducting material, in addition to asbestos packing. There are two separate coverings of the non-conducting material, and between these is a space of about 1½ in. tightly filled with asbestos packing, which entirely encloses the whole of the weighing mechanism, with the exception of the dial pointer. The opening in the underwork is protected from the heat or gases, while due precaution is taken to allow the load shackle to be in connection with the levers of the machine. The mechanism is so designed that the pointer comes to rest very quickly when indicating the load. When not in use, the machine can easily be hung up on wrought-iron loops, provided for the purpose.

The whole appliance has been designed and manufactured by Messrs. W. & T. Avery, Soho Foundry, Birmingham, to whom we are indebted for the particulars and illustration.

Latcher Method of Casting Wheels

A new method or form for casting car wheels has been patented by J. W. Latcher, of Edinburg, New York, U.S.A. The advantageous feature of the invention is the fluted-cored hole for receiving the axle after being bored. The wheel-seating surfaces of the axle are to be turned rough or V-threaded somewhat larger in diameter than the bored wheels, so that when the wheels are being pressed on the axle, channels or grooves will be ploughed in such threaded surfaces by wheels, and thus act as keys for securing the wheels rigidly to the axle. Figs. 1 and 2 illustrate this.

To determine whether the ordinary smooth-bored wheel, or the one secured by Mr. Latcher's method was the most firmly fixed, a testing apparatus was constructed for making a test of comparative resistance to torsion of car wheels on axle. One wheel was

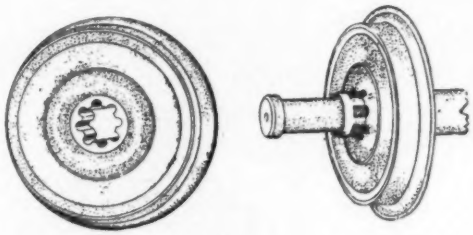


FIG. 1. FIG. 2.

THE LATCHER METHOD OF FASTENING WHEELS.

bored with a smooth round hole, the wheel-seating portion being turned smooth also, about 2 $\frac{15}{16}$ in. in diameter, being 0.004 in. larger in diameter than the hole in the wheel. The other wheel was made with a fluted hole, and bored 2 $\frac{7}{8}$ in. in diameter; the axle portion which enters the wheel was turned with a V-thread, 15 to the inch, and about in. larger in diameter on the periphery of the thread than the hole in the wheel. Both wheels were driven on the axle at a pressure of 28 tons. The test showed that the round hole and smooth axle twisted in its seat when the jack screw lifted the axle not exceeding 1,800 lbs. (900 lbs. on the end of each lever). The fluted wheel remained fixed to the axle in this test.

A pair of car wheels and axle one-sixth full size, with fluted-axle receptacles, and made in all respects as full-sized wheels and axle, were fitted up with clamp levers secured to wheels, and power was applied to lever ends while the axle was held in the proper position. The axle was twisted one-half round by wheels, which did not lose their grip on the axle.

Small Arc Furnace.*

The system of embedding metallic poles in the sole of an electric steel furnace for laboratory use has little to recommend it, the metal of the poles being more or less fused during the working of the first charge, so that the cells in which they are contained become filled with slag, which prevents contact between the poles and the charge in subsequent operations.

An ingenious system has been applied to an electric furnace, capable of treating about 4 cwts. of metal, at the works of the Société Anonyme des Aciéries et Forges de Firminy, Loire, France. The crucible is lined with several layers of blocks containing a certain proportion of carbonaceous material, the carbon content of which diminishes from the metallic casing of the crucible toward the surface of the furnace bed. The blocks are heated to a high temperature, which treatment causes them to become sufficiently conductive; and when they are re-cooled, this conductivity is partly retained. This system, however, gives poor results for furnaces of small capacity, because the conductivity of the blocks is relatively low in comparison with that of the metals and of the electrode

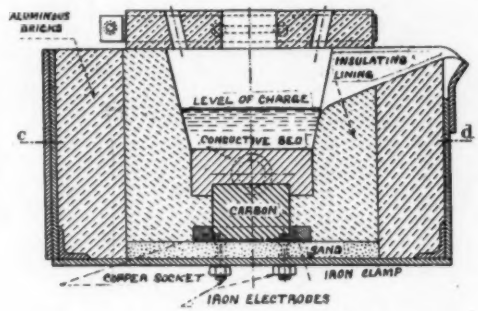


FIG. 1.—SECTION ON A.B. FIG. 2.

carbons. Hence there is a relative loss of energy, the importance of which is greater on account of the low total energy.

To overcome these defects a furnace has been constructed at Imphy with a single electrode (though others of the same polarity may be added). The portion in contact with the charge consists of a layer of blocks, containing very little carbon, and just thick enough to form the bed of the furnace. This bed rests on one or more carbons attached to the metal shell of the furnace by a thin copper socket, of sufficient dimensions to transmit the number of amperes of current required for the efficient working of the furnace. In this way, that part of the bed which has a relatively high electrical resistance, is reduced to a minimum, and the energy absorbed for that resistance is sufficient to heat merely that portion of the bed that is in contact with the charge—a very useful feature in furnaces designed for the fusion of small quantities of metal.

The furnace, of which sectional views are given in Figs. 1 and 2, consists of a metal shell, connected with one pole of a dynamo, and lined all round with a layer of aluminous bricks, for the sole purpose of lessening the waste of heat by radiation. The bottom is covered, for the same purpose, with a layer of white siliceous sand of very low conductivity, the refractory lining, properly so-called, of the furnace, being arranged inside these insulating materials. The carbon conductor already mentioned is placed in the bottom of the furnace, resting on the sand and connected at the base with the copper socket, electrical connection being established between the copper and the metal shell of the furnace by four copper bolts passing through the layer of sand. The carbon block is embedded in the mixture of magnesia or tarred dolomite usually employed for the basic lining of furnaces or converters, and projects above the same for a distance of ½ to 1 in., in order to make contact with the conductive bed, which is recessed for that purpose.

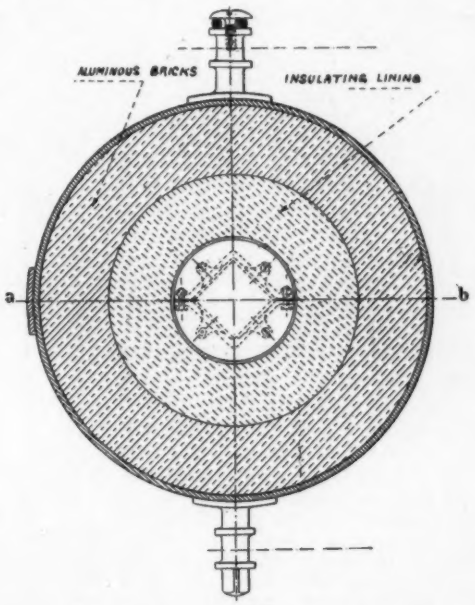


FIG. 2.—SECTION ON C.D. FIG. 1.

The furnace is stationary, but can be constructed so as to tilt.

Owing to the precautions adopted for preventing loss of heat and minimising the waste of electrical energy, the furnace is able to melt charges of 35 to 56 lbs. of metal, with an efficiency of 25 per cent. This laboratory furnace has already done good service in experiments with special steels, and the same principle can be applied to furnaces capable of treating one or more tons of metal. In one trial, 28 lbs. of mild steel, containing 0.1 per cent. of carbon, were melted per hour, with a consumption of 18 kilowatt-hours of current (350 to 400 amperes). The calculation of the amount of heat required to heat the steel to a temperature of 1,700 C., gives the thermal efficiency of the furnace as 32 per cent.

* M. Pourcel in "Revue de Métallurgie."

The Keith Fan.

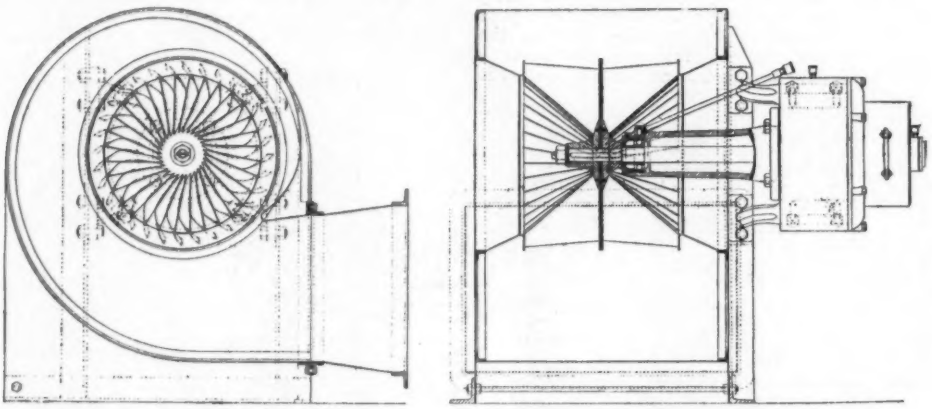
For the efficient handling of air for forced or induced drafts, the Keith fan, illustrated herewith, claims to possess special advantages. It is constructed in the usual sizes from 5 in. diameter air-inlets and upwards, in both single and double air-inlet form. In the sizes ranging from 5 in. to 17½ in. inlets, both the fan case and the wheel are formed of light sheet steel, but if desired, the fan cases may be of cast iron. In the single air-inlet variety of this fan the wheel takes the form of a double-conical truncated cone, composed of curved blades of conoidal formation, having their deeper or inner ends set obliquely to the wheel axis, the longitudinal edges of the blades lying on conical surfaces differently inclined to the axis of the fan spindle.

In the double air-inlet fan, the wheel takes the form of two double-conical truncated cones of different angles, conjoined, having two air-inlets, and built up of two sets of blades of similar form to those in the single air-inlet wheel, connected to side rings and to a central disc, both sets of blades having their concave surfaces set for running in the same direction. The diameters and proportions of the wheel, and longitudinal edges of the blades, are similar to those for the single air-inlet fan.

In both single air-inlet and double air-inlet Keith fans, the wheel is enclosed in a volute case. The thirty-two conoidally formed and parabolically curved blades of the wheel in each case have an axial length of a little over 1½ times their average radial depth. The mean diameter in each case of the inlet-centre of the drum is fully twice the average radial depth of the blades; the longitudinal edges of the blades being further apart at one end than at the other, and of different angles. The blades are thus much shallower towards the air-inlet or inlets than they are at the back or base end in the case of the single air-inlet wheel, or, toward the centre, in the case of the double air-inlet wheel. Owing, again, to the outside diameter of the fan wheel being greater at the air-inlet end or ends than at the disc, it follows that the blades are located further apart at the air-inlet end or ends than they are at their base, so that more air is drawn in or induced at the outer ends of the blades than at the inner ends.

The blades themselves are neither screwed nor twisted, but their peculiar form and special curve, and their setting on the disc (bringing their deeper ends obliquely across the axis), give, in addition to the usual scooping, inducing, and forcing action, a screwing action on the air. In most forms of multi-blade volume-pressure cased fans, the strongest air current is invariably at the base or disc ends of the blades, the tendency being to cause re-circulation of the air through between the blades at the inlet ends and thus back into the wheel centres.

Unlike such forms of fan wheels having relatively long narrow blades, the Keith fan wheel, it is claimed, by reason of the varying proportions, different angles and conoidal formation of the obliquely set blades, ensures the air delivery being absolutely equalised along the whole length of its outer blade edges, and there is consequently an entire absence of any kind of air blow-off at any point of the air inlets, as there too often is at some point on the air-inlet edges of other forms of fans.



LONGITUDINAL SECTION. TRANSVERSE SECTION.

FIG. 1.—DIRECT ELECTRICALLY-DRIVEN DOUBLE AIR-INLET KEITH FAN.

Some typical outputs of the Keith fans are stated to be as follows:—

A single air-inlet fan, with comparatively small inlet opening and fan case 29 in. high, delivers 1,200 cubic feet of air per minute, against 2 ozs. pressure per square inch, with wheel running at 1,200 revolutions per minute, and using 0.9 h.p.

A single air-inlet fan, with 12½ in. diameter eye opening and fan case 29 in. high, delivers 3,200 cubic feet of air per minute at a pressure of 1.9 ozs. per square inch, with wheel running at 1,460 revolutions per minute, and using 2.9 h.p.

A double air-inlet fan, with 12½ in. diameter eye or inlet opening and fan case 29 in. high, delivers 7,000 cubic feet of air per minute at 1 oz. pressure, with wheel running at 1,100 revolutions per minute, and taking 3.4 h.p.

It may be noted that the Keith fan, in either single or double air-inlet form, may be used for pressures up to 3.47 ozs. per square inch, with the same high efficiency shown for the lower pressures.

The makers, to whom we are indebted for the foregoing particulars, are Messrs. James Keith & Blackman Company, Limited, 27, Farringdon Avenue, London, E.C.

An Emergency Cupola.

The cupola illustrated herewith has been designed as a convenient auxiliary to have available for making castings which are urgently needed for break-down work. It is also found very useful for melting test mixtures, or for pouring castings which have missed or cannot wait for the next blow from the ordinary cupola. The furnace has also been found very advantageous for the "feeding" of large castings which require that to be continued after the ordinary cupola has ceased to melt.

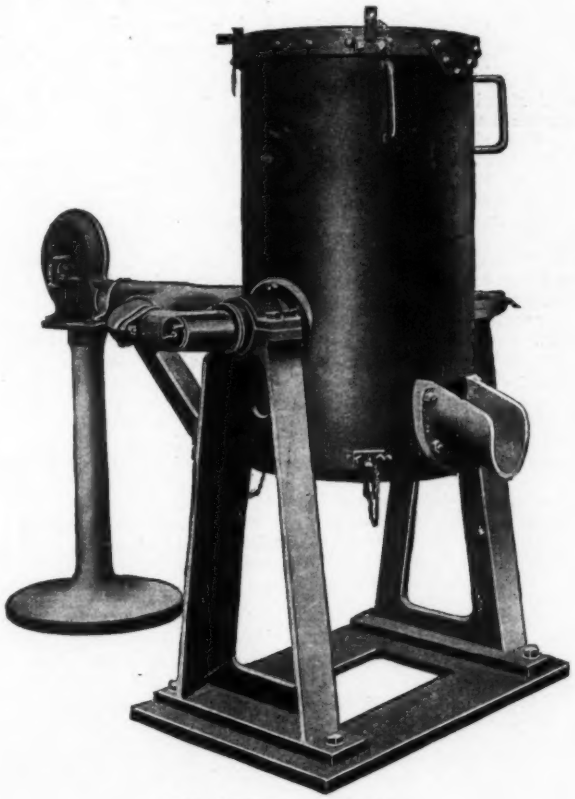
The blast is admitted through two hollow trunnions which form the tuyeres and are furnished with two suitable bend pipes fitted with sight holes, so arranged that any slag which may find its way into the same may readily be removed without causing choking of the blast pipes. To the two bend pipes is coupled a "Y" shaped pipe, which connects the fan to the furnace, and which is fitted with a blast gate.

A belt-driven fan for providing the necessary blast is mounted upon a substantial cast iron column, as illustrated, the power required to drive the fan being about ½ h.p. If required this fan can be direct motor-driven.

The furnace is fitted with a drop bottom and two pouring spouts, the top spout being available in the event of the bottom one becoming choked with chilled iron or slag, in cases where the furnace is used only for melting at intervals. For continuous melting there is, of course, no need to pour at the top spout.

The lining of the furnace is of ganister, rammed round a wooden plug of suitable size. A locking arrangement is fitted for keeping the furnace in a vertical position when melting.

The maximum melting capacity of the furnace is 10 to 15 cwts. per hour.



THE EMERGENCY CUPOLA.

The makers are Messrs. George Green & Company, Keighley.

MR. R. MASON, who is well-known among foundrymen for his work on behalf of the British Foundrymen's Association ever since its establishment, and who is a member of the National Council, and Vice-President of the Birmingham Branch has just left the Essex Works of the John Wright and Eagle Range Company to take up a position in the Catherine Street Works of the same firm. As a token of their friendship and as a souvenir of their pleasant associations with him, his colleagues at the Essex Works presented him on February 13 with a gold watch, and his wife with a gold-mounted umbrella.

Aluminium in the Foundry.

By A. Napier.

The industrial uses which were promised for aluminium, during its earlier history were legion, and this very fact resulted in many founders experiencing disappointment when they attempted to adopt the metal. There accordingly resulted a period during which it fell to a great extent into disfavour, and even now, while it meets with increasing popularity for a number of purposes, there are somewhat severe limitations imposed on its use. Being an extremely soft metal when unalloyed with other metals, it cannot often be used in its pure state for general industrial purposes.

The general moulding practice common in the brass foundry is followed with aluminium founding, but since that metal is far more liable to de-oxidation when molten than are any of the brass mixtures, and since also the shrinkage of aluminium in cooling is very great, special allowances have to be made to combat these features. The shrinkage for pure aluminium may be taken as about 6.5 per cent., but by alloying with other metals this is reduced considerably, about 1.3 per cent. being the shrinkage of the average aluminium alloy used. This shrinkage must be duly considered or cracks and depression will result; the precautions to be taken are in the preparation of the mould, and the pouring temperature of the metal. Large gates are advisable, and risers should be employed to a greater extent than with other founding; chills, too, can also be used to a great extent with advantage, to produce even shrinkage through the rapid setting of the thicker parts.

Alloys of Aluminium.

For the majority of purposes the addition of some other metal, or metals, is necessary in order to produce an alloy of sufficient hardness to stand some rough usage, but since aluminium unites with most of the common metals only to form definite chemical compounds which crystallise out in a matrix of practically pure aluminium, the question of producing a suitable alloy is a difficult one. Among the metals which crystallise out in this manner are iron, copper, nickel, antimony and tin; but on the other hand zinc, magnesium and manganese form solid solutions with the aluminium. Several alloys of aluminium and one or other of these metals are being produced and used under trade names by various makers, particularly in Germany, and amongst those which have attained positions of importance may be mentioned aluminium-zinc alloys with more than 15 per cent. zinc, these being very suitable for castings; more than 25 per cent. of zinc gives a very hard metal. The automobile industry has given considerable scope for the use of such alloys, the lightness of the castings being of great importance. An alloy of this nature which finds considerable use contains 15 per cent. zinc and 2 per cent. copper. On the other hand, many users object to such a high percentage of zinc, as it is claimed that it tends to form crystallisation which is liable to result in inopportune fractures. This feature, particularly for an automobile work, where considerable vibration must be withstood, is a serious one; and one American concern is stated to use exclusively an alloy of about Al. 92 per cent., and copper 8 per cent.

Another alloy which has proved itself extremely useful is magnalium, which is aluminium with a small per centage of magnesium. Unlike other additions, magnesium does not increase the specific gravity of the metal, while at the same time it does materially increase the hardness and improve the mechanical properties. Early experiments with magnesium were inclined to use too much of that metal, for the cost is high. Eventually, however, about 10 per cent. was proved to give an excellent effect, and as a matter of fact commercial magnalium of to-day contains much less than 10 per cent. magnesium, many samples having no more than 2 per cent.

Some of the magnalium alloys used for castings contain percentages of other metals, such as copper, tin nickel and lead; one authority states that a strong casting is obtained with 1.76 per cent. copper, 1.16 per cent. nickel, and 1.60 per cent. magnesium. Such a metal requires a good deal of care in casting, as indeed do all aluminium mixtures. The metal should be melted at as low a temperature as possible, this being somewhere about 660 degrees, under a layer of charcoal, and the scum should be carefully removed before pouring.

Other aluminium alloys containing 3 per cent. to 5 per cent. of copper are used to some extent for automobile work, while nickel is also used as a hardening agent in place of the copper.

Moulding.

In preparing the moulds it is not desirable to ram them as hard as is usual for brass casting, and though the amount of the gases given off is not very great, owing to the low pouring temperature of the metal, the moulds should be well vented. The moulding sand should be rather finer than for brass casting, and it is also considered good practice to mix the sand with a tenth part of metal to facilitate the free escape of gases. The face of the mould should be treated with black-lead, French chalk, or petroleum and lycopodium powder. The cores should be similar in composition to those used for brass work, but since the temperature of the lighter metal is lower, they should not be made so hard as for brass casting. Free venting is desirable in the cores also.

Melting.

One great source of trouble with aluminium melting is the rapid oxidation of the metal, and in this connection it is said that the beneficial effect which magnesium exercises is largely due to the power of freeing the aluminium from dissolved oxide. The oxidation is so rapid that it has at times been found practically impossible to remelt aluminium turnings unless they were first tightly bundled, and every possible precaution taken against contact with the air. With scrap aluminium particularly, the oxide, the specific gravity of which is close to that of the aluminium itself, produces a thick pasty mass, and the loss of metal through the skimming which becomes necessary is large. The presence of any of this pasty mass in the mould would, of course, be deleterious to the casting. As in brass founding, recourse may be had to covering the metal with charcoal, but even this has its drawbacks, for small bits of charcoal are liable to enter the mould with the metal. Salt, as a flux, finds favour with many brassfounders, and this material may be used as a flux for aluminium, but since the temperature of the metal is not very high, the results are not entirely satisfactory. Chloride of zinc has been used as a flux, and is said to give excellent results, particularly with castings containing a percentage of zinc. The chloride of zinc is thrown on the surface of the molten metal after it has been removed from

the furnace and has been cooled in the usual way to the desired temperature by adding scrap. Only small quantities of the fluxing material are required, and when this is thrown on the surface of the metal it should be thoroughly stirred. The fine powder or oxide of aluminium which results on the surface of the metal is readily skimmed off, and the aluminium left clean for pouring.

Oil and gas furnaces, when of a suitable design, often prove more economical than the pit furnace and crucible, but as both nitrogen and hydro-carbon gases are readily absorbed by the molten aluminium, due preparation must be made to carry off the products of combustion and prevent them coming into contact with it. The crucibles from which the metal is poured should be first heated to about the temperature of the molten metal. The pouring should be as rapid as possible and for very fine castings the temperature should be lower than for heavy work.

Repairing Castings by Burning-in.

Numerous solders for aluminium have been tried and found wanting, and many a casting has been "scrapped" for the want of a satisfactory method of repairing. If sufficient care is taken, however, a casting can be repaired by the "burning-in" process, which is common with other metals, and for castings that have been subject to a considerable amount of machining this method would often prove a great source of economy. "Burning-in," however, has not as yet met with a great deal of favour; in fact, it has seldom, if ever, been tried by the general founder.

Aluminium in Brass.

For making yellow brass castings in sand, aluminium has come much into favour as an addition, for it enables the metal to run better and fill with more exactitude intricate moulds. The presence of dross in such castings has, however, to be encountered at times. This results either from the use of too short a runner, or pouring the metal too hot. Owing to the extra fluidity imparted to the metal by the aluminium it need not be poured at so great a heat as would otherwise be necessary.

"Acme" Hand-Power Blowers.

The annexed cuts, Figs. 1 and 2, depict types of small hand-power "Acme" blowers. The design shown in Fig. 1, is made in three sizes, viz., (*a*) with a blast equal to 24 in. bellows; (*b*) with blast equal to 30 in. bellows; and (*c*) with blast equal to 36 in. bellows. It is suitable for use in connection with a rivet forge, or any ordinary smith's fire. It is constructed to work at 700 revolutions per minute, giving a volume of air of 30, 45, and 70 cubic feet per minute in the three sizes respectively.

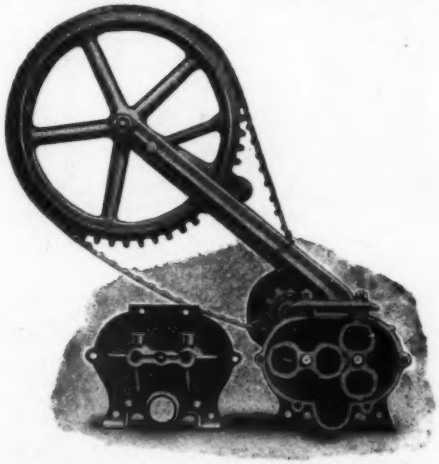


FIG. 1.—"ACME" HAND-POWER BLOWER FOR RIVET FORGE OR SMITH'S FIRE.

Fig. 2 shows a form of the blower designed for use by one or two men, and is applicable to two ordinary smith's fires.

With the exception of the cage inlet these blowers are made entirely of iron and steel, and have phosphor-bronze bearings. The working parts being accurately machined and practically air-tight, the blast given out is a positive one, a result not obtainable in machines under Roots' earlier patents. The revolvers or pistons are of new shape, giving a steady, even, and effective blast; they are, moreover, mounted on stout steel spindles. The blowers can be arranged to be driven by belt power, if desired, and in shops where power is available have been found to be in advance of either fans or bellows, and also of machines of earlier design; the gears on the revolver spindles are machine-cut and run in oil wells, and in the case of the machine shown in Fig. 2 are fitted with gears at each end.

FIG. 2.—"ACME" HAND-POWER BLOWER FOR TWO SMITHS' FIRES.

For the above particulars and illustrations we are indebted to the makers—Messrs. Samuelson & Company, Limited, of Banbury.

The Bickford Oil Crucible Furnace.

The application of kerosene and such like oils to crucible furnace work has not received a great deal of attention from founders, but under some conditions it can be made the source of both economy and convenience.

The illustrations herewith show a type of furnace (Bickford's patent) for melting brass and other alloys and metals, the fuel employed being waste oil or kerosene. The furnace is constructed of stout sheet metal lined with fire-clay and ganister baked by working the furnace for half-an-hour. Thus any intelligent man can re-line the furnace as well as when new.

Fig. 1 shows in section the apparatus with the warming cylinder in position. Oil stored in the air-tight reservoir (W) flows through the cock (T) into the filter tank (N) containing the filter (O). When the oil level in N reaches the end of the pipe (T_1)

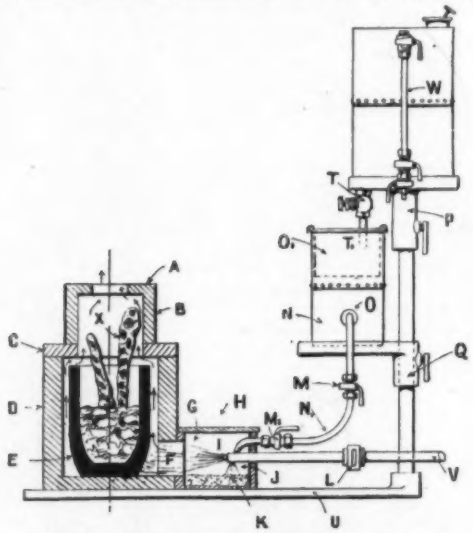


FIG. 1.—ARRANGEMENT AND ACTION OF THE BICKFORD FURNACE.

the flow from W stops (as when a bottle of water is inverted in a tumbler). The level of the oil in N then remains constant. From N the oil flows through the tube (N_1) and the stop-cocks (M, M^1) to the oil spout, and thence round the air nozzle (I) to the slot (J) by the air issuing, from which it is blown to the bottom of the combustion chamber (K). The resulting flame is blown through the hole (F) into the furnace (D) around the crucible (E) and up through the warming cylinder (B) warming the overlapping charge (X). Air is supplied through the valve (L).

To start the furnace a wad of lighted waste is thrown into the combustion chamber, and the air turned on. The oil supply is adjusted till the flame shows 4 in. through the cover, or till the furnace smokes, and in half an hour the charge, if of brass, is ready.

Forty pounds of brass, it is claimed, can be melted in this time with half a gallon of waste oil, and starting the furnace all cold. The consumption of oil, of course, varies with the temperature required, and is also affected by the suitability of the air pressure for that temperature. The consumption just mentioned refers to the melting only of brass, giving metal hot enough for casting ingots and heavy bearings. For general work one ton of brass can generally be melted with about 40 gallons of oil, where not less than 80 lbs. is melted at one blowing and the temperature is not exceptional.

The maximum temperature obtainable with the furnace depends on the air pressure employed. Brass may be reduced to a molten state with a very low air pressure, but unless the blast is adapted to the work in hand the metal cannot be made hot enough for use. The following table gives the air pressures recommended for different work:—

Water gauge pressure 2 in. to 3 in. jobbing brass casting, such as heavy bearings and ingots.

Water gauge pressure 5 in. to 8 in. general brass foundry work.

FIG. 2.—THE COMPLETE APPARATUS OF THE BICKFORD FURNACE.

Water gauge pressure 8 in. to 12 in., fine brass casting and cast iron.

Water gauge pressure 15 in., ordinary malleable castings and fine cast iron.

Water gauge pressure 25 in., gives about the melting point of mild steel, and renders tool steel quite fluid.

A furnace made for one pressure will not work at another, errors of 20 per cent. not being important. The air nozzle, however, may be changed for a new one suitable for a different air pressure.

For bronze melting the waste of metal is small, while iron melts readily, but necessitates twice the fuel and time required for brass, the minimum air pressure being 10-in. water gauge. For melting steel the furnace is not to be recommended, though it is claimed that with a high air pressure (something over 25 in.) it will melt boiler punchings in a covered crucible. Malleable cast-iron work also gives an opening for the use of the furnace, but a high air pressure is required here also.

This design of furnace has the advantages of being self-contained and needing no foundations; it requires only a level space to take the bed-plate.

When hot these furnaces do not smoke at all, and with care they do not smoke when cold; but as a precautionary measure, a forge canopy is recommended, except in well-ventilated shops.

The following comparison of the relative costs of coke and oil melting was compiled from results obtained at the works of Messrs. Holman Bros., Camborne, when using this furnace for machine brass :—

Coke.

	Pence.
¼-cwt. of oven coke at 1s. 3d.	3.75
3½ per cent. waste of brass	8.4
Crucibles (20 charges at 5s. per crucible) ...	3
	15.15

Oil.

	d.
¾-gallon oil at 2½d., say	3.75
Crucibles (30 charges)	3.75
Waste of metal, 1½ per cent.	3.6
	7.6

As regards the oil fuel required we understand that anything may be used from petroleum down to melted palm oil. Green creosote (distilled tar) is very suitable.

The makers of the furnace are Messrs W. J. & C. Tyack, Limited, Camborne, Cornwall; to whom we are indebted for the foregoing particulars

Concerning the Bosshardt Casting Process.

In our issue of January last we published some particulars of the "Bosshardt" process for producing malleable castings; a process which, it is claimed, entirely obviates all annealing, and produces, as desired, qualities of castings designated:—(1) Soft and forge iron; (2) extra soft steel; (3) soft steel; and (4) hard tool steel.

We have now received from the Bosshardt Casting Process Company, Limited, of Leeds, some further information on the matter.

Professor Arnold, we are informed, visited the two works in France and Holland, where the process is in full operation, and reported on the same. The following are extracts from his report:—

Professor Arnold's Report.

"In accordance with your instructions, I witnessed, at two works, one in Holland and the other in France, the Bosshardt processes in practical and commercial operation. The proprietors of these works gave me great facilities to get the facts of the case, but only after a pledge given that their names and cost estimates should be for your private guidance only, and were not to be included in any published report. The only point upon which the managers of the two works refrained from giving me any information was as to the nature of the secret addition necessary for the Bosshardt process.

"About the year 1886 the essential principles of the method, namely, the melting of Swedish or other wrought iron; and, by means of a certain small addition, the obtaining of sound and ductile unannealed castings, were discovered, patented, and published by Nordenfeldt (of gun fame) and Mr. Oestberg, of Stockholm, Sweden. For various reasons the Nordenfeldt-Oestberg process, for producing what these patentees named "mitis" castings, was not a commercial success. The method was, however, developed and extensively used for research and instructive purposes in the steel works of what is now the University of Sheffield, and in February, 1891, I delivered the inaugural lecture of the Sheffield Society of Metallurgists, publishing figures identical with those yielded by the Bosshardt method, as determined on products made in Holland and France in my presence. It is certain that Mons. Bosshardt has for the first time made the process a commercial success, especially in the Dutch works I visited. There I found eight furnaces, each holding four graphite crucibles, and in each crucible was melted 90 lbs. of metal, so that the foundry was capable of making, and indeed I am satisfied has made, castings up to a weight of about one ton. I noticed, ready for delivery, several propellers weighing, I should judge, from 10 to 15 cwts. Taking the highest quality of material made at the Dutch and French works, the mean analysis of the castings was as follows:—Carbon, 0.25 per cent.; silicon, 0.10 per cent.; manganese, 0.10 per cent.; aluminium, 0.06 per cent.; sulphur, 0.03 per cent.; phosphorus, 0.03 per cent.; iron (by difference) 99.43 per cent.

"The castings in their unannealed condition readily bend double without cracking. They are almost invariably sound and very clean on the skin.

"I have to state that a very large item in the success achieved by Mons. Bosshardt is due to the fact that he has found out an excellent moulding composition and a special paint therefor.

"A valuable feature is the small quantity of coke required per ton of steel in the form of furnace used. In ordinary crucible practice, mild material like this requires about 3 tons 15 cwts. of coke per ton of steel, whereas in the Bosshardt process both manufacturers agree in stating that only 2 tons of coke per ton of steel are necessary."

Other Evidence.

Mr. F. G. Fairbank, M.I.C.E., of Messrs. Fairbank & Son, York, in a memorandum of a visit to the Suresnes Works, France, of the Soft Iron Foundry Process Company, Limited, states that he saw numerous castings made by the Company under the Bosshardt process for several well-known firms, including the Hotchkiss Gun Company, De Dion Bouton, Lorraine-Deitrich, Delaunay Bellville, the Turin Motor Company, and others.

The castings included fittings for guns, crank shafts, large helical screws and screw propellers: cylinder heads, crank cases, front axles, clutch and brake pedal levers for motor cars, and numerous other castings that would replace stampings or forgings.

Mr. Fairbank also inspected a battery of four furnaces, each furnace holding four crucibles, and each crucible having a capacity of eighty to ninety pounds of metal. The covers from the three furnaces that were working were removed, and, by the aid of blue glasses, could be seen, through the intense light, the crucibles in position in the furnaces, and, when the lids were removed, the molten metal in same.

A "bon-bon" (containing the additions to the metal) was dropped into each crucible by means of a tube, and the surface of metal sanded over; ten minutes later the crucibles were removed from the

furnaces and the casting commenced. The molten metal in the crucibles appeared to be very fluid, and ran cleanly and freely into the moulds.

Within ten minutes of the actual casting the moulds were "struck" and the castings released, and as soon as these were cool they were ready for the sand blast cleaning. The castings, eighty in number, were of all sorts and sizes, varying in weight from two-thirds of a pound to forty kilos., and they were invariably clean and free from "scabs."

The heaviest casting so far turned out at the Suresnes Works (with its four furnaces) weighed 400 kilos., but the making of castings of considerably heavier weights is, it is claimed, only a question of the increase of the number of furnaces, this being rendered possible owing to the arrangements for handling the crucibles, and the great fluidity of their contents.

Tests on the Metal.

Static (tensile) tests made on bars produced by the Bosshardt process at the Leeds University Engineering Laboratory by Mr. John Goodman, M.I.C.E., M.I.M.E., Professor of Civil and Mechanical Engineering, gave the following results:—

Test No.	Dia. inches.	Sectional area square inches.	Reduction in area per cent.	Extension per cent. on 6 ins.	Elastic limit Tons.	Tensile strength square inches.
2606	1.122	0.989	41.6	21.0	12.32	20.34

Remarks.—Fracture—fine grained with irregular specks.

University Test No.	Dia. inches.	Area in square inches.	Reduction of area per cent.	Extension per cent. on 6 ins.	Elastic limit in tons per sq. inch.	Maxi. stress in tons per sq. inch.
2617	1.121	0.967	52.4	33.5	10.88	20.94*
2618	1.112	0.971	11.3	7.5	11.50	23.73†

Remarks.—*Silky fracture. †Coarse granular fracture.

University Test No.	Dia. inc..es.	Area in square inches.	Extension per cent. on 8 inches.	Elastic limit in tons per sq. inch.	Maximum stress in tons per sq. inch.
2627	0.852	0.570	1.5 not broken	24.81	29.51 not broken

Remarks.—Specimen slipped through jaws.

An interesting feature of the test on specimen No. 2,617 is the substantial reduction in area and extension per cent. before the breaking point is arrived at. These bars were cast in the ordinary way, turned up by machine to the requisite diameter, and then submitted to the above tests, without being in any way hardened or tempered. The last test bar quoted was potass hardened.

We are informed that an arrangement has now been come to by the associated manufacturers of brass and copper tubes whereby the fluctuations in market values will in future be regulated by eighths of a penny. Recently prices for these classes of goods fell ¼d. per pound, but they have now been advanced ¼d. per pound, this being the first instance of a change in price under the new arrangement referred to.

Checkweighing in the Iron and Steel Trade.

Under the title of the "Compulsory Weighing and Measurement Bill, the draft of a proposed Bill "to provide for the weighing and measurement of the material used in the process of manufacture, as well as the product thereof, in all iron and steel works, cement works, lime works, and chalk quarries," has been introduced into the House of Commons A Departmental Committee sat to consider this question in 1907. The Bill now introduced is backed by Mr. Hodge, (Secretary of the British Steel Smelters, Mill, Iron, and Tinplate Workers' Amalgamated Association), and Messrs. Macpherson, Roberts, Henderson, Thorne, Clynes, Glover, Parker, Taylor, and Wardle of the Labour Party. The Bill, which is termed the Iron or Steel Works, Cement Works, Lime Works, and Chalk Quarries Regulation Act, 1909, provides that (1) in every iron or steel works, and in every lime works and chalk quarry, the material produced by the workman or workmen shall be truly weighed at such stage in the process of manufacture and in accordance with such rules as shall be prescribed by a Secretary of State; (2) that the persons employed by piece work in any iron or steel works, cement works, lime works, or chalk quarry may, at their own cost, station a person (in this Act referred to as a check weigher) at each place appointed for the weighing or measuring of the material, in order that he may, on behalf of the persons by whom he is so stationed, take a correct account of the weight or measurement of the material, as the case may be; (3) that every Act for the time being in force relating to weights and measures shall extend to weights, measures, scales, balances, steelyards, and weighing machines used in any iron or steel works, cement works, lime works, or chalk quarry in checking or ascertaining the wages of any person employed therein in like manner as if they were used in the sale of goods; (4) that where a check weigher has been appointed by the majority of the persons employed in any iron or steel works, cement works, lime works, or chalk quarry who are paid according to the amount of material worked by them, and has acted as such, he may recover from any person for the time being employed at such works, his proportion of the check weigher's wages or recompense; (5) that if the owner or manager of the works, or any person acting under his instructions, interferes with the appointment of a check weigher, or refuses to afford proper facilities for the holding of any meeting for the purpose of making such appointment in any case in which the persons entitled to make the appointment do not possess or are unable to obtain a suitable meeting place, or attempts to exercise improper influence in respect of such appointment, such owner or manager shall be guilty of an offence against the Act; (6) that in every iron or steel works, cement works, lime works, or chalk quarry the owner or manager shall, for the purpose of enabling each person who is employed on piece work to compute the total amount of wages payable to him in respect of his work, furnish in writing to each person so employed particulars of the rate of wages applicable to the work to be done by such person at the time when the piece work commences; (7) that any person guilty of an offence against this Act shall be liable on summary conviction to a fine not exceeding twenty pounds.

The centenary commemoration of the foundation of the Friendly Society of Iron Founders has been arranged for June 26, and will be held at Manchester.

Oxy-Acetylene Welding in the Foundry.

By F. H. Hurren.

It is only in the last two or three years that an efficient oxy-acetylene welding plant has been put on the market, but in that short time it has come much to the fore. By its aid, castings which would have to be scrapped can be efficiently repaired.

The price of a complete oxy-acetylene plant varies from £17 to £130, according to size and kind of plant installed. The cheapest is the portable plant, consisting of a cylinder of compressed oxygen, a cylinder of dissolved acetylene, a pressure regulator for each cylinder, a blowpipe, and two lengths of rubber tubing to connect the blowpipe with the cylinders. This plant is especially suitable for small repairs on aluminium, brass, gun-metal, cast iron, and steel articles.

The best type of blowpipe is the Fouché injector pattern, which is made in nine sizes, according to the class of work to be operated upon. For small repairs the No. 3 is a very useful instrument, but where an acetylene generating plant is installed, No. 7 and 10 will be found the most convenient.

In any class of apparatus the method of working is the same. The acetylene gas is turned on and lighted at the nozzle of the blowpipe. Oxygen is then admitted, and the gases regulated, until a colourless flame with a small white cone at the centre is obtained. The point of the cone is the welding flame, and gives the highest temperature, whilst the colourless flame around it being a reducing flame, the material is not liable to oxidation.

Take, for a first example, an aluminium casting which is necessary to be oil-tight, but has a small crack at one corner. The point of the white cone of the flame is brought to bear on the sound part of the casting, just above the crack. In less than a minute the metal at that point will become molten. The flame should then be caused to follow the outline of the crack, so that the edges melt, and with a fine-pointed tool the molten metal should be rubbed into the crack. If necessary, the same should be done on the other side. When cold, the casting can be trimmed up with a file.

In large cracks or gaps, where it is necessary to fill up with metal, one of the aluminium solders which are now so abundant, should be used. A groove is cut with a file along each edge of the repair, the flame brought to bear, and a stick of aluminium solder applied with a sliding motion along the groove. In about a minute the solder will melt and run into the groove. The flame should be kept playing until the edges of the crack begin to soften. The molten solder must be well rubbed into the groove with a thin piece of steel, until the solder appears to have alloyed with the aluminium. After cooling and filing up a clean repair will be found.

For brass and gun-metal, brazed joints can be made with much greater facility with oxy-acetylene than with the ordinary coal gas blow-pipe, and the joint is usually neater.

In copper castings for electrical work, small cracks often appear, and these may be easily brazed up by the aid of the oxy-acetylene plant.

As a general rule, repairs to cast iron and malleable iron require a large size blow-pipe, in order to have more surface heated at the one time. The join is usually made with a special ferro-silicon alloy, and to be successful it is necessary for this to alloy with the metal of the casting. For instance, suppose it is desired to weld a piece in a broken automobile cylinder. The fractured edges are cleaned as far as possible, and the pieces fitted together. A shallow groove is filed round the contour of the fracture, and the oxy-acetylene flame applied. When the metal becomes red-hot, a stick of the ferro-silicon is held in the flame. Just as this begins to get pasty, it is dipped in a flux (usually consisting of a mixture of borax and carbonate of iron), reheated in the flame, and a portion of the stick allowed to melt off into the groove. The flame is kept on until the body of the casting for, say, half an inch each side of the crack is just ready to melt. The fluid ferro-silicon is rubbed into the crack with a piece of steel, a little more flux added, again rubbed in and then allowed to cool. The whole outline of the fracture is treated in this way, and if carefully done, it will be found that on filing up, a good weld is obtained. Two things are essential for success; a large flame must be used, and the molten alloy must be well rubbed into the fracture.

In some instances, especially in rather large or intricate castings, in heating up or cooling down after welding, further cracks may occur. This can be obviated by first heating the whole casting in a furnace to a dull red, then performing the welding operation, and afterwards cooling down slowly.

Malleable iron castings are treated in practically the same manner as common iron, the preliminary heating being essential. The weld can be made either by the assistance of ferro-silicon or steel, and experience will soon teach which is the best method.

In the steel foundry, the welding process is particularly adaptable. Steel castings which are otherwise perfect, are often disfigured by "scabs." These should be cleaned out with a file, the oxy-acetylene flame brought into play, and when the surface metal is just beginning to melt, a piece off a thin steel rod melted into the hole. If dexterously performed, a perfect join is made, and after cleaning and polishing, it is impossible to detect the repaired part.

Castings which have "short run" in one place, can be filled up satisfactorily, and many other applications of the process also present themselves.

The above is only a very brief account of what can be done with the oxy-acetylene welding plant. The possibilities are manifold; it does not require very skilled labour, and anyone with a little experience can work it efficiently. The cost is comparatively small.

In consequence of the increased demand there may be for war vessels in the next few years, Messrs. Armstrong, Whitworth & Company have resolved to acquire more land for dealing with Admiralty work at a suitable place on the north bank of the Tyne, below Newcastle. The site of the new works of Sir W. G. Armstrong, Whitworth & Company will be close to the company's present premises at Walker. Rumours have lately been in circulation that a foundry at the Elswick Works of Sir W. G. Armstrong, Whitworth & Company, Limited, was to be closed, but we understand that the report is without foundation. The company have resolved to carry out certain extensions and re-arrangements of departments at their Scotswood Works, and included in these plans is an alteration of a foundry. A small foundry is to be shut up on one site, it is stated, but it will be opened out on another, and this doubtless gave rise to the report mentioned above.

A Miniature Open-hearth Furnace for Light Steel Castings.

By W. M. Carr.

At a meeting of the Philadelphia Foundrymen's Association, held on March 3, a paper was presented by Mr. W. M. Carr on "A Miniature Open-hearth Furnace and its Adaptation to the Production of Small Tonnages of Light Steel Castings Cheaply and Satisfactorily." The paper is given herewith, in abstract:—

Since the introduction of the Siemens regenerative system for the production of steel it has been found that by increasing the length of the furnace body, and at the same time increasing its capacity, considerable economy in fuel or producer gas resulted.

Large furnaces, accordingly, were constructed, and at present furnaces up to 200 tons capacity have been erected, while the maximum of fuel economy is attained with those of 40 to 50 tons capacity. These facts apply where the fuel used is producer gas. To use producer gas for steel melting requires special construction in open-hearth furnaces, so as to get the greatest possible thermal efficiency by increasing the distance the flame travels through the body of the furnace. A short furnace tends to burn out quickly at the ends, while a longer furnace secures with the same fuel a longer life of the refractory bricks.

The rapid growth of the steel-casting industry owes its impetus to the advantages, economically considered, of the open-hearth. The opinion, however, prevails that certain economies are confined to furnaces having 25 tons per heat as a maximum capacity and 5 tons as a minimum. Since, with producer gas as fuel, the weaknesses of the larger furnaces, as well as their steady fuel consumption during idle periods, exist also with open-hearth furnaces for castings, such furnaces must be kept going continuously to avoid collapse. Therefore, those of ordinary capacities do not lend themselves satisfactorily to small tonnages and irregular, intermittent operation.

In localities where fuel oil can be obtained at a reasonable cost as a substitute for producer gas, a new set of conditions arises. The calorific value of liquid fuel is high, and burning with regeneratively heated air in the hearth of a furnace produces an intensely hot flame and one free from the stratification common to producer gas. A body of producer gas entering an open-hearth has above it a layer of regeneratively supplied air. Combustion takes place mainly on the upper surface of the sheet of gas, and the calorific energy resulting must be radiated downward through a cooler, slower burning body of gas to elevate the bath of metal below to the high temperature absolutely necessary. The result is certain vortical movements of alternating hot and cooler gases and products of combustion, with the greatest elevation of temperature at a point some distance from the surface of the bath. The walls, sides, and roof become heated and radiate to some extent the heat generated by the combustion of the upper strata of gas, but as the radiation from the refractory walls diminishes with the square of the distance, being neutralised by the cooler intervening body of gas rolling over the bath's surface, the heating value of a lean gas is lost unless the length of flame travel be extended. Thus the fuel economy of a small or short hearth is poor with producer gas. On the other hand, the length of hearth is unimportant when burning liquid fuel. Combustion occurs immediately and the thermal effect is transmitted to the body of metal. There is no dilution of the fuel, as is the case with producer gas, other than a small quantity of air under pressure needed to atomise the oil. The flow of the fuel is subject to quite a delicate control and the flame can be made of any length desired. Radiation from the refractory walls is more active, tending to promote and intensify combustion.

The advantages of liquid fuel as a heating agent have proved very useful to the author in the development of the small open-hearth furnace that would not have otherwise been possible. To meet a demand for the production of steel castings in small quantities at irregular periods, the small open-hearth furnace, oil fired, offers certain economies not found in any other type of steel-making unit. Its advantages are:—(1) Low initial costs of installation; (2) absence of high power machinery; (3) ability to withstand intermittent operation; (4) low fuel consumption; (5) low labour and repair charges; (6) hot fluid steel of good quality; (7) the possibility of using up to 75 per cent. of scrap.

The writer in the course of research work designed, built, and operated an oil-fired open-hearth furnace of 5 cwts. capacity. The fuel consumption per ton of steel was found to run as low as 20 gallons, or 50 per cent. less than regular practice. This effect was due to the narrowed and restricted hearth volume, producing an active catalysis, and to the short distance between the surface of the bath and the highly heated refractory material of the walls and roof, bringing the whole into effective radiation. The charges were melted quickly and the temperature of the metal, when in readiness to tap, was found to be 100 degrees C. hotter than that of metal from a gas-fired furnace. The furnace was found to be extremely sensitive to heat control. Steel made under such conditions can be made super-molten, with the advantage that the furnace is not damaged in so doing. Super-heating in the ordinary gas-fired furnace results in a rapid erosion of the brick structure. Steel made in small open-hearth furnaces fired with oil can be tapped into hand ladles and poured into moulds without undue haste.

For commercial purposes a furnace of 1,000 lbs. capacity can be used when that quantity may be wanted regularly or at odd intervals. The whole cost of the installation does not exceed £400, and the equipment other than a furnace will be a storage tank, an oil pump, and a low-pressure blower. Such a furnace will make four heats in a day of twelve hours, yielding steel of the same composition as a standard acid open-hearth. The labour required will be that of a steel melter and a labourer. The fuel consumption will not exceed 40 gallons per ton, making allowance for keeping the furnace warm over night if running regularly.

In the discussion which followed the reading of the paper it was stated that while castings weighing from 45 to 50 lbs. had been poured most successfully by means of a lip ladle, leaving no skull, small thin castings such as are poured with steel made by some of the baby Bessemer processes had not yet been experimented with. The percentage of loss in metal in operating a 500-lb. open-hearth furnace of the Carr type, using a mix of approximately 66 2-3 per cent. scrap and 33 1-3 per cent. pig-iron, was said to be 8½ per cent., slightly greater than in general open-hearth practice. The adaptability of a furnace of such capacity was also commented on.

The Mixing of Iron for Castings.

British Foundrymen's Association: Birmingham Branch.

At a meeting of the Birmingham Branch of the British Foundrymen's Association, held at the Municipal Technical School, Birmingham, on February 27th, Mr. George Hailstone read a paper on "The Mixing of Iron for Castings," Mr. Robert Buchanan (President of the Branch) being in the chair.

A full abstract of Mr. Hailstone's paper appeared in the February number of the FOUNDRY TRADE JOURNAL, under the title of "The Scientific Mixing of Iron for Castings."

Discussion on the Paper.

MR. A. H. HIORNS, who opened the discussion, said that the paper was of immense value, because it contained a great deal of information which could not be obtained in any other way. There were no books which gave such exact information. The members were greatly indebted to Mr. Hailstone for giving them the benefit of his practical experience. Iron-founding was a much neglected trade, and it seemed strange that a metal that was so largely used, and the making of which employed so many thousands of workmen, should not have received the attention it demanded. The old craftsmen had the idea that they possessed a number of special secrets which were not to be disclosed, but they eventually found that other people had the same secrets, and that they might just as well have spoken out at once. It was undoubtedly a disadvantage that modern workmen did not always possess the necessary scientific knowledge to appreciate such lectures as that, and he thought it might be an advantage if a series of lectures could be given to members of the Association who had not had the same scientific advantages in their early days as some of them had had, with a view of bringing before them some useful elementary facts and terms. If they were willing he would be very pleased to have a series of six or eight such lectures in that place as part of the ordinary course of lectures next session. (Applause.)

It was generally said that pig-iron was not so good as it used to be. He thought that was the case to some extent, because people had scratched the surface of the ore mining districts and had obtained the best ores which were usually found to be close to the surface. As they went down deeper they found that the ores obtained were more impure, and contained more sulphur. They had been led to consider that there was a very considerable quantity of that element very deep down. (Laughter.) By the aid of the chemist they were able to get over the difficulties of impurities by the careful mixing of irons, and so get first-class results. With respect to the necessity of analysis he thought it a very extraordinary state of things that the buyer should be content to depend upon the seller as to the qualities of the material purchased. With reference to the sampling of pig-iron, he was inclined to disagree with the conclusions of Mr. Hailstone, and to think that it was not the best course to drill down the centre. He had found considerable differences in analysis in the different parts of the sample. He had once seen a sample of pig-iron which contained a quantity of mercury which came from nobody knew where. He understood from Mr. Hailstone that the use of phosphorus gave softness to the iron, but his own experience would not support that. With regard to the use of aluminium, Mr. Hailstone had rather thrown cold water on that metal, but he, Mr. Hiorns, thought that wherever trouble had arisen it must be through using too much. A small quantity must be an immense advantage, and if put into the metal immediately before tapping into the mould it would have a great effect in reducing the blow-holes. The paper showed the immense advantage of scientific work in the increasing of output and economical production

MR. F. J. COOK (President of the National Association), speaking on the question of buying by analysis, said that the use of this method was so obvious that he wondered it was not more extensively adopted. Probably one reason was that foundrymen had not made up their minds as to what they exactly wanted, and he did not think they would get any proper standard until the blast furnaceman and foundryman met together to discuss the question. Probably, standards could not be fixed for all the furnaces in the country, but surely they might be for certain districts. At present the pig-iron numbers were nothing at all to go by. Often they varied between two furnaces, and sometimes between consecutive casts from one furnace.

With regard to the use of bulky coke, it seemed to be an advantage and more economical to use a light coke that would fill up a bulky furnace without adding to the weight. That question was very well worthy of consideration. With regard to the effect of blast pressure on the action of the blast furnace, that deserved further consideration, and was largely a matter which every foundryman would have to find out for himself, but the trouble was that at present it was entirely disregarded.

MR. W. J. FOSTER entirely agreed with Mr. Hailstone that phosphorus was a softener in cast iron. But it was necessary to be careful in reducing the phosphorus not to have an equivalent in the total carbon, or they would only get a harder casting. The secret of the whole thing seemed to be that the purer the iron the softer the casting.

MR. PEMBERTON strongly argued for the employment of a chemist, and for co-operative employment of one by firms whose premises were not sufficiently large to justify the exclusive services of a chemist. He had an impression that foundrymen would not object to taking iron even if it were inferior provided that they knew its constituents, but they wanted more candour on the part of the blast furnaceman. The silicon seemed to be the most varying feature, and it was the element which most frequently got the foundryman into trouble.

MR. THOMAS regretted that the reader of the paper had made no reference to mechanical tests. Although the paper was of very great value they must remember, with regard to purchase by analysis, that there were very many types of castings, especially in Scotland and in Manchester, in which analysis was of little value. For example, bedstead castings, grates, and ranges, were productions in which chemical analysis did not matter. As long as the iron was strong enough to hold up the grate into position that was sufficient. He did not think, either, that chemical analysis was necessary for pipe founding. The whole thing resolved itself into a commercial question. He had strenuously advocated purchasing by analysis for the more important castings, but till

everybody came into line and demands were made upon the blast furnaces they would have irregularity. At present, the seller could dispose of his iron for certain work without bothering about analysis, but for all kinds of engine castings it was most essential. As to the qualities of coke, he would consider 8 per cent. ash rather high for a good class coke. He would like to know whether Mr. Hailstone recommended titanium, which has been a good deal discussed lately.

Mr. Pooler quite agreed that it was important to know whether one could make as good a casting with a cheap as with a dear pig-iron.

The Chairman said that while he was an advocate of analysis he did not regard it as a panacea for everything, but he was certain that it gave the greatest percentage of accurate results of any system he knew. It carried them further than anything did on the road they wanted to travel. But the real obstacles were the rule-of-thumb foundrymen. He thought the suggested series of lectures by Mr. Hiorns would be immensely valuable to those who left school forty years ago and had had no opportunity of learning the alphabet of science. Another obstacle was the non-progressive blast furnace people who compelled the buyer to rely upon the numbers. He hoped the time would come when blast furnacemen would realise that they had got to either analyse or go out of the business. He was sure they would have to come into line, because already a demand was growing up among foundrymen for a more dependable system of classification, and this was beginning to be recognised by the merchants. The question was becoming one of national importance in view of foreign competition.

Mr. Hailstone, replying on the discussion, said that there were many elements of cast-iron which he had not had time to deal with. He did not agree that pig-iron was poorer than it used to be. He had sampled some ancient as well as modern specimens, and he had never analysed better in his life than some lately produced of the kind now sold. With regard to the phosphorus in small castings, phosphorus was used because it increased the fluidity. Total carbon was a most important element, and the other elements merely altered the form of the carbon. As to the value of chemistry in an iron works, he knew cases where the want of knowledge of chemical constituents led to a waste of at least four shillings or five shillings per ton on every ton of iron used. Scientific mixing would have produced as good results or better with materials costing that much less.

On the motion of the Chairman, the proceedings concluded with a hearty vote of thanks to Mr. Hailstone for his paper.

British Foundrymen's Association.

Birmingham Branch.

A visit was paid by members of the Birmingham Branch of the British Foundrymen's Association on Saturday, March 13, to the Birmingham Municipal Technical School. Mr. A. H. Hiorns (Head of the Metallurgical Department) received the party, which numbered about fifty, and included Mr. Robert Buchanan (the President of the Branch), and Messrs. R. Mason, Grant, Fraser, Bullock, Reason, Knight, sen., Craig, Heggie (the Hon. Secretary), and others.

Mr. Hiorns conducted the visitors over the various departments of the school, explaining the general arrangements and especially those of the metallurgical and engineering and other departments, specially interesting to the visitors. The work done in the various laboratories and shops was fully described. Classes, as a rule, are not held on Saturday afternoons, but owing to the great pressure on the accommodation—as the result of which proposals are now being made for an extension of the building—a few students were found at work in the machine drawing class room and the electrical wiring and iron shops. The visitors were deeply interested in all that they saw, among the things which attracted particular notice being the excellent arrangements for heating and ventilating the building on the plenum system. Mr. Buchanan proposed a hearty vote of thanks to the Committee of the School for the permission given for the visit and to Mr. Hiorns for his courteous conductorship. Mr. Buchanan said that they had on many occasions been indebted to Mr. Hiorns for services rendered to their Association, and they had to thank him for having enabled them to spend a most interesting and profitable afternoon.

Mr. Knight seconded the motion, which was carried with enthusiasm.

Mr. Hiorns, in reply, said that it always gave him pleasure to meet the members of the British Foundrymen's Association, and to do what he could to assist those who were seeking to increase the knowledge of the constitution and uses of metals.

Queries.

Defects in Cast-Iron Moulds.

We have to make numerous iron castings which are parts of moulds used in the manufacture of glass bottles. These moulds are similar to a half-round brass bearing, and they vary in thickness from ¼ in. to 1 in., and in weight from 1 lb. to 14 lbs. The inner

surface must be clean and shapely, and accordingly they are cast in the manner shown in the illustration, with several small V runners along the side. The trouble is that some of the castings come out with a groove along the centre of the inner surface very much like that left by a scab. Can you suggest a remedy?

"J. R. S."

Replies.

Slow Melting.

In reply to "J. B.," who is having trouble with his cupola, the specified melting capacity of which is theoretically one ton per hour, the theoretical capacity is never attained in practice. The idea that if more air can be blown in, a better melting ratio will be the result is eroneous. If too much air is blown in, too much carbon-dioxide (CO_2) is accumulated, necessitating more coke to bring about the reaction from CO_2 to (CO) carbon monoxide. The trouble does not finish here, for the excess of oxygen attacks the silicon and manganese, the result being slower melting, a poorer product and more slag. For a cupola of the dimensions specified better results will be obtained if the tuyere area is reduced from three to two of 4 in. diameter each. If a larger fan is introduced the lining will suffer considerably. No fixed rule can be given, the best remedy is to keep a careful watch from day to day. For cupolas a brick having the approximate analysis will answer your purpose.

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K & Na
77.30	19.17	1.43	0.45	0.6	1.10

"A Moulder."

The "Foundry Trade Journal" Bookshelf.

Malleable Cast Iron.

By S. Jones Parsons, M.E. London; Archibald Constable & Company, Limited.

So little has been published in book form on the subject of malleable cast-iron that this volume will prove very welcome. There is, perhaps, no branch of the iron industry on which so little is known as on the manufacture of malleable castings. The trade has had to combat ignorance and prejudice on all sides, both on the part of the user, and often too on the part of the producer, and this has resulted in the use of such material coming into favour comparatively slowly. Definitions of malleable cast-iron vary considerably, and in view of the fallacies which are current on the subject in many trade circles, the author of this book, before coming to the technical side of the question, proceeds to place the status of malleable cast-iron on a firm basis, showing it to be in reality a form of steel and not, as is often supposed, of wrought-iron. He further quotes from the report on "The Uniform Nomenclature of Iron and Steel," presented at the Brussels Congress of the International Association for Treating Materials, in 1906, the definitions there given being delightfully vague. The author then proceeds to consider the various questions of foundry practice and draws attention to the difference between melting and mixing irons for malleable castings and for ordinary grey castings and to the preparation of the cores and moulds to suit the special characteristics of white iron. The subjects of moulding and core-making are not exhaustively treated, a somewhat brief but concise outline being given. Annealing naturally occupies a considerable portion of the book. The construction of ovens for this purpose is first considered, followed by the theory of annealing; the treatment of hard castings; packing; charging; firing; drawing; and other points in the process. Methods and apparatus for cleaning and straightening the annealed castings are then described and illustrated. The design of castings is, of course, an important matter, and some stress is laid on the necessity of considering the law of crystallisation in this connection. In a chapter on "Patterns," the author deals with the contraction of the castings, machining allowance, metal patterns, and other matters of importance to the patternmaker, and following this comes the question of inspection and testing. Supplementary processes, such as case-hardening, pickling, galvanising, etc., are also briefly dealt with, and in conclusion are some notes on malleable cast-steel. Scientific detail is conspicuous by its absence, the book being essentially of a practical nature.

Molesworth's Pocket-book of Engineering Formulæ.

London; E. & F. N. Spon, Limited, 57, Haymarket.

This well-known annual has long been firmly established in favour, a fact which is sufficiently testified by the appearance of its 26th edition. As in former issues, the enterprise of its authors is admirably maintained in the additions and alterations which have been introduced, in order to preserve the character of the publication as in every respect an up-to-date handbook. In this edition, such alterations and additions are very considerable, but by a judicious substitution of new matter in the place of that which has become obsolete, coupled with condensation wherever possible, the size of the volume is not materially altered from that of former issues.

Foundry Practice.

By James M. Tate and Melvin O. Stone, M.E. London; Chapman & Hall, Limited.

This book claims to rival neither in size nor contents the popular hand-books for the technical man. It is compiled to serve as a text-book on foundry practice for the student with very little knowledge of workshop practice and phraseology. In this respect it stands alone, as far as we recollect; for practically every other work on foundry practice has been written for the foundryman with a good knowledge of the general principles of his work, and consequently, with this knowledge presumed by the authors, early students have found themselves hampered. In this book the principles of foundry practice are set forth concisely and clearly, and the authors have made no attempt to compile a complete and elaborate treatise on the subject. The treatment of the different operations is necessarily brief, since the book covers all the ordinary work in foundry practice, both brass and iron, but numerous examples are given representing different kinds of moulding. Particularly lucid and concise are the descriptions of green sand and dry sand moulding with which the book opens, while the chapter devoted to "Moulding sand, moulders' tools, moulding machines, and equipment," contains a good deal of information that will be appreciated by the student. The information on equipment includes core-boxes, core machines and drying ovens, blowers, cleaning apparatus, hoists, etc. In many instances the descriptions of these appliances are accompanied by illustrations; some of the latter, however, can hardly be accepted as representing the most modern designs. Otherwise, the information given is extremely useful. Pig-irons, we note, do not come in for treatment to any great extent, but particularly useful sections are the glossary of foundry terms, which is fairly comprehensive, and a series of useful tables on melting points, the strength of iron, shrinkage, and the relative weights of patterns and castings, etc. The book was prepared for the use of students in the College of Engineering, University of Minnesota (U.S.A.), and it may safely be described as a successful attempt to meet the needs of the student, at any rate as an introduction to foundry work. There are others, too, who would profit by a study of the book, for both the authors are men of wide experience in the foundry trades.

A Text Book of Physics: Heat.

By J. H. Poynting, Sc.D., F.R.S., and J. J. Thomson, M.A., F.R.S., etc. London; Charles Griffin & Company, Limited.

This treatise on Heat is the third of a series of text books on physics, and is, moreover, the third edition (revised). The book is designed for students who are studying particularly the experimental part of physics, and accordingly it has not the tone of an advanced treatise on a special subject. The mathematical methods adopted are comparatively elementary, thus allowing its scope of usefulness to extend to many who have not received an advanced mathematical training, and further, only such phenomena as are of special importance, or which appear to throw light on other branches of physics, are dealt with. The book opens with a chapter on temperature, consideration being given to the construction of mercury-glass thermometers, platinum resistance thermometers, and other heat-measuring apparatus.

Following that, the expansions of solids, liquids, and gases under the influence of increased temperature are separately considered, the subject being ably explained and illustrated, as also is the principle of circulation and convection in fluids. A very interesting section of the book deals with the various forms of energy and the conservation of energy, and here is introduced, in connection with the mechanical equivalent of heat, Mayer's calculation from the specific heats of air at constant pressure and constant volume. The researches of Joule and other experimenters are also quoted in considerable detail in this chapter. The succeeding chapters in turn deal in an exceptionally clear manner with the kinetic theory of matter; change of state—liquid vapour and solid; water in the atmosphere; the theory of exchanges; radiation and temperature, and thermo-dynamics. The style of treatment throughout the book should prove very acceptable to the general student, for while it is far from being a mere primer on physics, the language and style of explanation are not encumbered with advanced scientific detail. A fair knowledge of mathematics is, of course, essential to an intelligent study of the work, and with this the volume will be of considerable interest and utility. Diagrams and illustrations of the experimental apparatus, numbering nearly 200, are used to assist the anthors' explanatiors, making a volume of some 350 pages in all.

Report of Tests of Metals and other Materials for Industrial Purposes.

Washington, D.C.: Office of the Chief of Ordnance.

This is a report of tests made with the United States testing machine at Watertown Arsenal, Massachusetts, during the twelve months ending June 30, 1907, and includes tests on such material as tubes and jackets, shot and shell, steel wire, Monel metal, copper cylinders for pressure gauges, wheels for field carriages and limbers, railway material, cement, concrete and mortar columns, bricks, stone, etc. The results of the tests are tabulated, and numerous diagrams are used to illustrate the text.

Falling Sales Yet Increased Profits.

By Harvey Preen. London: Simpkin, Marshall, Hamilton, Kent & Company, Limited.

This little book claims to show how manufacturers and business men generally can increase their profits even when business is not good. The author emphasises the importance of efficient internal organisation of manufactories, and the value of scientific cost systems, and gives instances of the advantages derived by the application of the principles inculcated. Hints are given as to methods to be pursued in order to attain the object set out in the title. The style is bright and interesting, and the book well worth reading.

Directory of Directors for 1909.

House, Old Broad Street, E.C.

By Thomas Skinner. London; 77 to 81, Gresham

This well-known publication is now in its 30th year of issue, and has long established itself in public favour as a complete and reliable list of directors of the joint stock companies of the United Kingdom, as well as of the companies themselves, including useful and interesting particulars concerning them. From the preface we learn that through death and other causes nearly 1,900 names have dropped out of the Directory during the year 1908, while a slightly larger number of new men have come in, the total number of names now reaching 20,900.

Metal Working. Part I.

Edited by Paul L. Hasluck. London: Cassell & Company, Limited.

This is a new publication described as "a book of tools, materials, and processes, for the handy man." Its title indicates an ambition as regards scope which many may think it hardly likely to be satisfied by the prospective issue of the work in 24 weekly parts. The first part now to hand comprises 32 out of the projected 740 pages. It begins with a table of the physical qualities of all the known metals, with their specific weights, strength, melting points, etc. It then goes on to deal with metal work in the foundry. This section of the work is not completed in the part under review but, so far as can be gathered, it appears to be written on practical lines. A large number of line illustrations of a good type are included, and altogether, judging from the initial issue, the work promises to be a useful one for the handy man.

Report of the Mining and Metallurgical Industries of Canada, 1907-08.

Ottawa: Published by Dr. Eugene Haanel, Director of Mines.

This voluminous report, extending to over 970 pages, has been issued to meet the increasing demands made on the Canadian Department of Mines for information on the mining and metallurgical industries of Canada. The work comprises matter descriptive of all the metallic and non-metallic mineral mines and metallurgical and clay industries in the Dominion, from the Atlantic to the Pacific. It is illustrated by some 144 engravings and drawings, and mineral maps of the respective Provinces. The maps alone add great value to the report, since not only are they up-to-date as regards the topography of Canada, but the locations of known metallic ore and commerical mineral deposits, being worked, are marked thereon. A brief historical sketch prefaces the industrial review of each Province; and a description of the magnitude, equipment, and mode of operation of every important mine and plant mentioned is given, together with the capitalisation and *personnel* of each organisation or company. In a copious index some 1,500 names of owners, or companies, are recorded alphabetically.

New Catalogues, etc.

ALFRED WISEMAN, Glover Street, Birmingham. Copy of a catalogue of scales and weighing machines, ranging from small laboratory scales to large weighbridges.

THE BROWNING ENGINEERING COMPANY, 6, 7, and 8, Crutched Friars, E.C., send us their illustrated catalogue of their standard lifting magnets, for use in connection with crane work.

C. AKRILL & COMPANY, LIMITED, West Bromwich. A handsomely designed and well-illustrated catalogue of the specialities which they manufacture for rolling mills, foundries, and engineering establishments, has been issued by this firm. It gives a short history of their Golds Green Foundry, with some photographic views of same, and descriptive particulars and illustrations of rolls, gearing, engineers castings, etc., which they have turned out.

STURTEVANT ENGINEERING COMPANY, LIMITED, 147, Queen Victoria Street, E.C. A copy of a new issue of Section 90 of their illustrated catalogue of Sturtevant "Steel Plate" fans, M.V. type, has been sent to us by the above firm. These fans have been designed to give the maximum volume of air against relatively small resistances with the least expenditure of power, and to take up a minimum of space.

Inventions.

Applications for Patents.

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An asterisk indicates that a complete specification accompanies the application. When inventions are communicated the names of the communicators are in brackets.

—o—

1909.

3,926. Mould for casting metal. C. F. Gaywood, 33, Cannon Street, London.
3,961. Regenerating gas furnaces for melting steel. J. Izzett, 96, Buchanan Street, Glasgow.
4123. Furnaces. Bell Brothers, Limited, and W. L. Johnson.
4176. Automatic weighing apparatus. W. E. Hipkins and J. J. Burrows, Soho Foundry, Birmingham.
4330. Furnaces. D. Love.
4553.*Electric furnace. Aktiebolaget Elektrometall.
4,666. Press for moulding retorts, pipes, etc. B. Beddoe, J. B. Gregor, and John Lysaght, Limited.
5,360. Production of magnets from cast-iron for use in electric magnetic machines. F. Burke, 55, Market Street, Manchester.
5,487 Casting metal objects. J. Pschenitzin and W. Iwanoff.
5,549.*Annular gas furnace with a central pillar. C. Deselle.
5,700. Moulds for casting metals or ingots. R. Haegele.
5,712.*Purification of molten metals. E. T. Fennell and J. Sackett.
5,802. Metallurgy of iron and steel. W. S. Simpson and H. Oviatt, 173, Fleet Street, London.
5,838. Furnace grates. A. Esplen, Tower Building, Water Street, Liverpool.
6,049. Metal castings of electric fuse boards. V. Hope, 55, Market Street, Manchester.
6,220.*Inlay casting machines. J. A. Johnson and C. M. Hedman.
6,224. Furnace for hardening, annealing, and heating small repetition work. H. H. Hayes, 12, Prince of Wales Terrace, Beeston, Notts.
6,446. Machine for bending pipes, etc. J. Major, Flixton Road, Flixton, Manchester.
6,561.*Regenerative reverberatory furnaces. O. Friedrich, 31, Bedford Street, London.
6,610. Furnaces used for the melting of metal, etc. J. C. Barker and Bosshardt Casting Process, Limited.

Abstracts of British Patent Specifications recently accepted.

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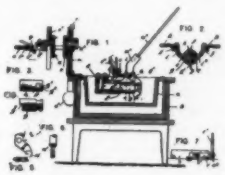
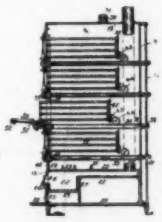
130 (1908). *Casting Apparatus.* H. H. Doehler, manufacturer, 84, Buckingham Road, Brooklyn, New York. —The invention relates to casting apparatus, embodying a melting pot and pump. The main object is to provide an apparatus of this character wherein the plunger will be so supported relative to the cylinder as to be substantially free thereof at all times except when the metal is being forced from the cylinder, while being caused to accurately register therewith when actuated, thus preventing the jamming, brazing, or soldering of those two parts during those intervals when the apparatus is not being operated. A further object is to support the plunger when it is withdrawn from the cylinder proper as to minimise the area of the contacting surfaces within the melting pot of the plunger and its support. The plunger may be actuated by a lever, which acts to both force the plunger within the cylinder and withdraw it without the use of pivotal connection between those members. A still further object is to provide an apparatus wherein the cylinder will be filled through its core, thus causing the entrance of the plunger to the cylinder to close same and place all the metal therein under pressure. Fig. 1 is a longitudinal section of a casting apparatus embodying the invention; Fig. 2 is an end view of the cylinder and the plunger support; Fig. 3 is a plan view of the plunger; Fig. 4 is a side view thereof; Fig. 5 is a side view of the head of the operating lever; Fig. 6 is an end view thereof, and Fig. 7 is a side view of the locking mechanism for the bottom plate or support for the die. Carried by the melting pot a in a manner to be submerged in the metal contained in the pot, is a cylinder c having a discharge nozzle d leading from its upper forward end, the port of the nozzle



Doehler's Casting Apparatus.

being in communication with the interior of the cylinder. Extending from the rear end of the cylinder is a plunger support preferably cast integrally therewith, composed of a cylindrical portion e cut away so as to form a plurality of narrow longitudinal guides f adapted to engage and support the plunger g when it is withdrawn from the cylinder, and afford a large clearance space for the admission of the metal to charge and recharge the cylinder c, through the core thereof. The plunger support has diametrically opposite ways h h^1 for the passage of the lever actuating the plunger. To avoid the presence of pivotal bearings in the molten metal a special construction of plunger and actuating lever is provided, which not only serves to apply power to the plunger in either direction, but concentrates and applies such at all times substantially axially of the plunger. To avoid the entrance of metal to the cylinder from the top of the melting pot the forward end of the plunger g is undercut at g^3, thus leaving an overhung top guard, while providing ample space for the passage of the molten metal to the cylinder.

6,113 (1908). *Core Ovens.*—(Communicated by G. H. Wadsworth, Corner of Third and Portage Streets, Cuyahoga Falls, Ohio, U.S.A.). The invention has particular reference to devices of the type in which a series of drawers are employed, the drawers having

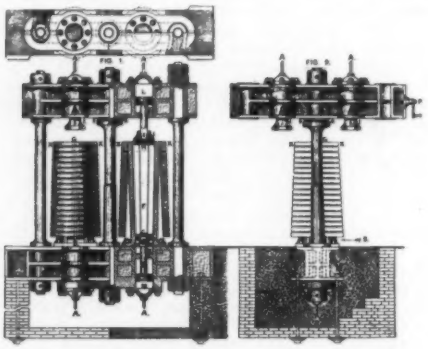


An Improved Core Oven.

rollers at their back ends running on guides underneath the drawers, and in which each drawer of a series is provided with a separate horizontally-hinged door. The invention consists primarily in an arrangement whereby the drawers are provided at their rear ends with rollers and at their forward ends with parts adapted to telescope into stationary tubes provided on the oven casing.

The annexed cut is a vertical section of the oven. The front plate 16 is provided with a series of openings through which the core drawers 17 pass. Extending from front to back of the furnace beneath these openings are the tubes 35, there being two tubes for each opening. These tubes are preferably screw-threaded at their front ends into the front plate 16 (which has a reinforcing boss 36 at this point) and at their rear ends the tubes pass through the two plates 11 and 12 of the oven back, being locked in place by the two nuts 37 and 38 screwing on to the tube and bearing against these plates. At the front end a suitable nut 39 screws on to the tube and bearing against the boss 36 securely locks the tube at this point. These pairs of tubes for each opening are thus stationary and form rigid braces for the oven from front to back. When the drawer is closed, the tubular rod 47 extends entirely through the tube 35. When the drawer is drawn out this rod draws out with it, supporting the front end of the drawer, as shown in the case of one of the drawers in the illustration. To allow the cores to be conveniently placed, the front plate 50 of the drawer is hinged to the front casing 45, so that the front plate may be tipped down into horizontal position, being so supported by lugs 51 carried by the plate 45. When the drawer is closed, the front plate 50 is turned up vertically and held by a latch 52 thereon, turning behind a lug 53 provided on the front plate.

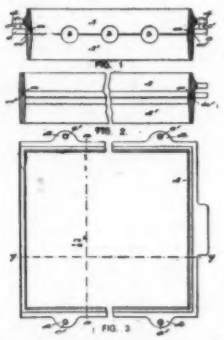
3,408 (1908). *Apparatus and Method for the Casting and Fluid Pressing of Taper or Conical Steel Ingots.* W. Lees, 2, Earle Street, Manchester Road, Ashton-under-Lyne. This invention consists in the arrangement of a double or twin hydraulic press, which provides for



Apparatus and Method for the Casting and Fluid Pressing of Taper or Conical Steel Ingots.

the casting and pressing of two ingots at one time. The moulds are secured on the bed of the press, the ingots being cast the smaller end downwards, there being provision for expansion and contraction, also arrangements for ejecting or lifting the ingot from the mould together with an opening in the bottom of the mould, which provides for observation, for cooling, and the introduction of refractory material on the head of ram. The apparatus is described by the following reference letters :—A :—Combined feed and blow-off pipes, (connected with the accumulator by flexible armoured tubes, or pipes, and suitable valves or taps). B :—The opening at the bottom side of the ingot mould, level with the flange or base of the mould which is bolted to the bed plate of the press. C :—The slab of refractory material, the same being cut or moulded to the required shape. D :—Loose grooved head of ram, on which rests the slab of, say, burned fire clay. E :—Bottom piston or rod, the centre entering the bottom of the ram D. F :—Octagonal ingot mould of properly or suitably arranged taper, strengthened by longitudinal strips, ribs, or feathers, tapering the reverse way of the mould and on which rest (and are closely gripped by) the forged steel hoops X. G :—Open top of the mould ready for the molten steel to be poured in. H :—Slab of burned fire clay or other suitable material, cut to the shape or moulded to the shape and size of the mould at the top. I :—Head of the top ram. J :—Top piston and rod. K :—Cylinder space under top piston. L :—Cylinder space over top piston. M :—Cylinder space under bottom piston. N :—Space to receive ram D. when lowered. O :—Roller or ball bearings on which rests the headstock. P :—Screw bolt for locking the headstock when in position. X :—Forged steel hoops, properly arranged for constant grip. Fig. 1 shows a front view of the press and moulds, while Fig. 2 shows a side view, the headstock being swung round on its roller or ball bearings.

5,912 (1908). *Moulding Boxes for Foundry Use.* Meynell & Sons, Limited, of the Cleveland Works, Montrose Street, Wolverhampton, and A. E. Guest, of the same address.—This invention relates to moulding boxes, for foundry use, which are formed in two or more parts (usually an upper and lower part only) which when put together to form a complete box rest one upon another. Two box-parts are to fit together, one with a male slanted or bevelled rim and the other with a corresponding female slanted or bevelled rim to receive the male rim. The bearing surface in each case is conveniently formed to run along the four sides or the entire circumference of each box-part, but this is not essential so long as it occurs in sufficient places for the purpose. Figure 1 is a transverse section taken on line $x\ x$ of Figure 3, looking in the direction of the arrow a x, Figure 2 is a longitudinal section taken on line $y\ y$ of Figure 3, and Figure 3 is a plan view. A is one of the box-parts which make up the box, and A^1 the other. The box-part A is formed with an externally bevelled rim a, and the box-part A^1 with an internally bevelled rim a^1 into which the bevel of the rim a fits,



Foundry Moulding Box, by Meynell & Sons, Limited.

and these rims are so constructed, as shown, that should any wear of their bevelled surfaces take place they will still close up tightly against one another and ensure the accurate fitting together of the box-parts. Under all circumstances, therefore, the pressure of one box-part against the other will be simply through the bevelled faces. Both the bevelled faces are shown as continuous along both sides and ends of the box, except where (as in the particular box illustrated) holes b are formed through one end of the box, through which the metal is poured in casting; but it will be obvious that this is not necessary, as the purpose will be effectively answered if short or discontinuous lengths of bevelled faces occur in sufficient places to ensure that when the box-parts are put together neither can turn in any degree in relation to the other. The box-part A^1 is shown with ears c to which are fixed tapered pegs c^1, and the box-part A is shown with ears d having holes therethrough to receive the outer ends of the pegs c^1. These pegs, however, are for the purpose merely of guides in putting the box-parts together, and the holes through which they pass in the ears d need not, therefore, be fitted to the pegs with the accuracy which would be necessary if their purpose was also to ensure the accurate fitting together of the box-parts.

Trade Talk.

THE TEES-SIDE BRIDGE AND ENGINEERING WORKS, LIMITED, have removed their London offices to 36, Lime Street, E.C.

MESSRS. WHITEHOUSE & COMPANY Stourbridge Road, Halesowen, have added a new moulding shop to their iron foundry.

IT is anticipated that the amalgamation of the Society of Engineers with the Civil and Mechanical Engineers' Society will be completed this year.

MR. F. C. HEMMENS, 10, Howard Road, Westbury Park, Bristol, has been appointed by the Falkirk Iron Company as their agent in the West of England.

THE petition of John Shaw & Sons, Wolverhampton, Limited, to wind up the Reading Iron Company, Limited, has been dismissed, but without costs.

MESSRS. H. A. PROCTER and L. Ramsbottom, engineers, Norwich, trading under the style of Procter, Ramsbottom & Company, have dissolved partnership.

A DISSOLUTION of partnership is notified in connection with Messrs. C. P. Yarwood and P. A. Yarwood, brass founders, Birmingham, who traded under the style of C. P. Yarwood.

THE BRITISH GAS FURNACE AND TOOL COMPANY, LIMITED, Birmingham, have received an order from a Chilian railway company for one of their latest type of case-hardening furnaces.

MESSRS. C. W. LEAVITT & COMPANY, importers and selling agents of ores, metals, and alloys, have removed to the Hudson Terminal (Cortlandt Building), 30, Church Street, New York, U.S.A.

MR. F. O. ROBINSON, 65, Sparkenhoe Street, Leicester, who is the hon. secretary of the Leicester district branch of the Engineering Employers' Federation, has started in business as an agent for foundry requisites.

MESSRS. W. WHITE, T. H. Bacon, and C. J. Baker, engineers, etc., Budge Row, London, E.C., trading under the style of William White & Company, have dissolved partnership, so far as regards Mr. C. Baker.

MESSRS. G. ELLIOTT & COMPANY, engineers, etc., of 186 and 188, Long Lane, Bermondsey, London, S.E., have converted their business into a private limited liability concern, under the style of G. Elliott & Company, Limited.

THE petition of Messrs. Brownlie, Murray & Company, of Possilpark, Glasgow, for the winding-up of the Aluminium Corporation, Limited, has been dismissed without costs in the Chancery Division by Mr. Justice Swinfen Eady.

A DISSOLUTION of partnership is notified in connection with Messrs. R. Jobson, A. Jobson, R. Jobson, Junr., and T. A. Jobson, West Hartlepool, Durham, who traded under the style of Robert Jobson & Company, engineers, etc., so far as regards Mr. R. Jobson.

THE STOCK EXCHANGE COMMITTEE have ordered the undermentioned securities to be quoted in the official list:—Vickers, Sons & Maxim, Limited—Further issue of 50,000 ordinary shares of £1 each, fully paid Nos. 3,500,001 to 3,533,714 and 3,673,215 to 3,689,500.

MESSRS. S. RUSSELL & SONS, Bath Lane, Leicester, have purchased the engineering and foundry premises at Syston of Messrs. Cort, Paul & Cornick, together with all the working plant and patterns, and are intending to carry on the business without interruption.

MR. F. W. HARBORD, consulting metallurgist and analytical chemist, has entered into partnership with Mr. Edward Riley, metallurgical and consulting chemist, and the two businesses will in future be carried on under the style of Edward Riley & Harbord.

THE SCHMIDT SUPERHEATING COMPANY, LIMITED, has opened an office at 28, Victoria Street, London, S.W., under the charge of Mr. H. A. Stenning, as consulting engineer for the locomotive department, and Mr. A. F. White, as consulting engineer for the marine department.

MESSRS. T. C. S. RATCLIFF, B. RATCLIFF and M. R. RATCLIFF, brassfounders, Birmingham, trading under the style of Joseph Ratcliff & Sons, and as tube manufacturers, Great Bridge, Staffs, under the style of Ratcliff & Ratcliff, have dissolved partnership so far as regards Mr. T. C. S. Ratcliff.

THEODORE BUTLER, LIMITED, 149, Queen Victoria Street, E.C., have been appointed European representatives of the Rogersford Foundry and Machine Company, Philadelphia; the W. N. Durant Company, Milwaukee, Ohio; the Buckeye Manufacturing Company, Louisville, Ohio; and the Oswego Tool Company, Oswego, N.Y.

THE UNION ELECTRIC COMPANY, LIMITED,, of Park Street, Southwark, London, S.E., notify us that for some seasons past it has been their custom to lend lantern slides of their apparatus for lecture purposes, and that they will be pleased to hear from engineers, technical instructors, etc., who desire to make use of them.

IN the London Court of Bankruptcy, last month, creditors and shareholders met under the winding-up order made against the Fulham Steel Works Company, Limited. The liabilities were returned at £37,815, of which £12,776 was expected to rank, against assets estimated at £11,636, after deducting £24,819 for preferential claims and loans on debenture bonds. The liquidation was left in the hands of the Official Receiver.

THE partnership hitherto subsisting between Messrs. Heman Coulthurst, Jeshurun Coulthurst, and Armena Coulthurst, carrying on business as ironfounders and engineers, at Robert Street Foundry, Darwen, under the style of H., J. & A. Coulthurst, has been dissolved. The business in future will be carried on under the same style by Messrs. Alameth Coulthurst, Edwin Coulthurst, and Alcimus Coulthurst, sons of Mr. Heman Coulthurst.

W. & F. WILLS, LIMITED, of Perseverance Works, Bridgwater, have purchased all the patterns in the brick and tile machinery trade of Messrs. James Culverwell & Company, Bridgwater Engineering Works, who have now retired from business. Messrs. Wills have also bought many of their other patterns besides all their working drawings, and are in a position to do any necessary repairs or renewals to machinery of Messrs. Culverwell's make.

THE status prize will be awarded by the Society of Engineers each year for the next five years ending 1913 (if papers of sufficient merit are received), for the best paper written by any person on the subject of "How to Improve the Status of Engineers and Engineering, with Special Reference to Consulting Engineers." The prize will be three guineas' worth of books and instruments, to be chosen by the successful author. The essay is not to be more than 6,000 words in length, and for the present year is to be sent in addressed to the Secretary of the Society of Engineers, 17, Victoria Street, Westminster, S.W., by June 30 next.

THE Secretary of the Institution of Mechanical Engineers announces that in connection with the Bryan Donkin Fund, applications for grants in aid of original research in mechanical engineering may be sent to the Council during the current year. The first award will be made in February, 1910, and the amount available will be about £27. The Bryan Donkin Award, consisting of the interest on the sum of £360 6s. 6d., will be made triennially, beginning in 1910. In the event of no grant being made, or the grants made amounting to less than the sum available, the surplus will be devoted to aiding the Research Committees of the Institution.

THE NORTH BRITISH LOCOMOTIVE COMPANY, LIMITED, Glasgow, are carrying out extensive alterations and additions at their Queen's Park Works. An order has been placed with Messrs. Smith, Wincott & Company, 53, Waterloo Street, Glasgow, for the new gas-fired furnace plant, including ten forging, five plate heating, one bar heating, and a number of case-hardening furnaces, as well as the chimneys, and a battery of Smith & Wincott's patent gas producers. This firm have also recently completed some extensive contracts both at home and abroad, including among the latter the design and erection of all the forge, plate heating, bar heating, bronze melting, bolt heading, tool hardening, etc., furnaces, iron foundry cupolas, core stoves, galvanising and lead baths, steel chimneys, etc., all of which are gas fired, for the Taikoo Dockyard and Engineering Company of Hong Kong, Limited.

Personal.

MR. J. FIELDING, of Fielding & Platt, Limited, has been made a J.P. for Gloucester.

MR. J. OLIVE has been elected assistant secretary of the Friendly Society of Ironfounders.

VISCOUNT HOWICK and Mr. G. F. Tweedy have been elected to the board of Swan, Hunter & Wigham Richardson, Limited.

MR. W. J. CROSSLEY, M.P., is resigning his position as chairman of Crossley Bros., Limited, and will be succeeded by Mr. Kenneth Crossley.

LORD CLAUD JOHN HAMILTON has joined the board of Hadfield's Steel Foundry Company, Limited, in succession to Sir Howard Vincent.

MR. G. F. MARTIN, general manager of the Blaenavon Company, and Mr. O. Thomas, chief engineer, are making a business visit to the United States.

THE late Mr. Josiah Vavasseur, a director of Armstrong, Whitworth & Company, Limited, left property amounting to £311,742, of which £275,555 is net personalty.

THE late Dr. Francis Elgar, LL.D., F.R.S., chairman of Messrs. Cammell, Laird & Company, and the Fairfield Shipbuilding and Engineering Company, Limited, left estate of the gross value of £81,046.

MR. E. T. JUMP was recently the recipient of a presentation from the Manchester 2 Branch of the Friendly Society of Iron Founders, in recognition of 28 years' service as an officer of the branch.

MR. J. LYLE has been the recipient of a presentation from the officials and men and friends on his retirement from the position of general manager of the Uskside Engineering Company, Limited, Newport.

PROFESSOR HUMBOLDT SEXTON is retiring at the end of the current session from his position as chief of the Department of Metallurgy in the Glasgow and West of Scotland Technical College, after 25 years of service.

MR. THOMAS BELL, of John Brown & Company, Limited, Clydebank, is to take the place of the late Dr. Elgar, as representative of the Institution of Naval Architects on the Engineering Standards Committee.

MR. PETER MUNNOCH, of Middlesbrough, lectured on "Cast Iron and Foundry Practice" before the members of the Keighley Association of Engineers, at the Technical Institute, last month. Mr. T. S. Clapham presided.

SIR GERALD A. MUNTZ, BART., has been elected sole managing director of Muntz Metal Company, Limited, in place of the late Sir P. A. Muntz, Bart., who was senior managing director and deputy-chairman of the company. Mr. A. H. Wiggin has been elected deputy chairman.

MR. GEORGE MOORE, who has occupied the position of locomotive superintendent for the North-Eastern Railway Company at Annfield Plain for 35 years, and has been altogether in the service of the company for 42 years, has resigned, and Mr. R. Atkinson, of Gateshead, has been appointed to succeed him.

MR. A. GRACIE, who has for some years occupied the position of managing director of the Fairfield Shipbuilding and Engineering Company, Limited, has been elected chairman of the company in succession to the late Dr. Francis Elgar, F.R.H. Mr. Gracie is also a director of Cammell, Laird & Company, Limited.

MR. JAMES MALCOLM HAY has resigned his seat on the board of Vickers, Sons & Maxim, Limited, after a connection with the company of over 37 years. The directors have decided to fill the vacancy by the appointment of Mr. Vincent Cartwright Vickers, who had for some time been a special director on the London local board.

New Companies.

JOHN BELL, LIMITED.—Capital £10,000 in £1 shares, to purchase the business of John Bell, engineer and ironfounder, of Wishaw.

DEWS BROS., LIMITED.—Capital £10,000 in £10 shares, to take over the business of lock manufacturers, etc., carried on by F. Dews and H. Dews at Moseley Street, Wolverhampton, as Dews Bros.

BARNES & SYKES, LIMITED.—Capital £6,000 in £5 shares, to carry on the business of engineers, founders, smiths, machinists, etc. Registered office: 9, Walker Street, Rochdale.

AITCHISON, BLAIR, LIMITED.—Capital £12,000 in £1 shares, to carry on the business of engineers, boilermakers, etc., and to adopt an agreement with J. W. Aitchison and A. Blair, trading at Aitchison, Blair & Co.

FREDK. MOUNTFORD (BIRMINGHAM), LIMITED.—Capital £10,000 in £1 shares (5,000 preference), to acquire the business of F. Mountford at Fremo Works, 66A, Granville Street, Birmingham, and to carry on the business of engineers, etc.

WINNING, MELLIS & Co., LIMITED.—Capital £2,000 in £1 shares, to acquire the business of Winning, Mellis & Co., millwrights, ironfounders, etc., of Mountblue Works, Camlachie, Glasgow. Registered office; 70, Mountblue Street, Camlachie, Glasgow.

GROSVENOR MANUFACTURING COMPANY (ASTON), LIMITED.—Capital £2,000 in £1 shares, to take over the business of ironfounders, carried on at Bute Works, Beales Street, Aston, near Birmingham, as the "Grosvenor Manufacturing Company."

SHARP & SONS, LIMITED.—Capital £2,500 in £1 shares, to acquire the business of general engineers, etc., carried on at Camelon Engineering Works, Falkirk, under the style of William Sharp & Sons. Registered office: Camelon Engineering Works, Camelon, Falkirk.

J. JEFFERIES & SONS, LIMITED.—Capital £20,000 in £1 shares, to take over the business of engineers, boiler makers, shipbuilders, and repairers, etc., carried on by J. Jefferies, J. W. Jefferies, and A. Jefferies at Blackhorse Lane, Hotwells, and Avonmouth, as J. Jefferies & Sons.

GODFREY JOHNSON PATENT CORRUGATING COMPANY, LIMITED.—Capital £30,000 in £1 shares, to adopt an agreement with G. B. Johnson and to carry on the business of ironfounders, engineers, gutter and trough makers, iron and steel converters, etc. Registered office: 2, Pancras Lane, E.C.

TOLLEY & COMPANY, LIMITED.—Capital £1,000 in £1 shares (500 preference), to take over the business of brassfounders carried on at 186, Cheapside, Birmingham, as Tolley & Company, and to adopt an agreement with H. Williams and H. Causer. Registered office: 186, Cheapside, Birmingham.

LOCKERBIE & WILKINSON (TIPTON), LIMITED.—Capital £20,000 in £1 shares (6,000 preferred), to take over the business of iron, steel, constructional and general engineers, etc., carried on by D. Green and Annie H. Green, at Workhouse Lane, Tipton, and elsewhere, as Lockerbie & Wilkinson (Tipton).

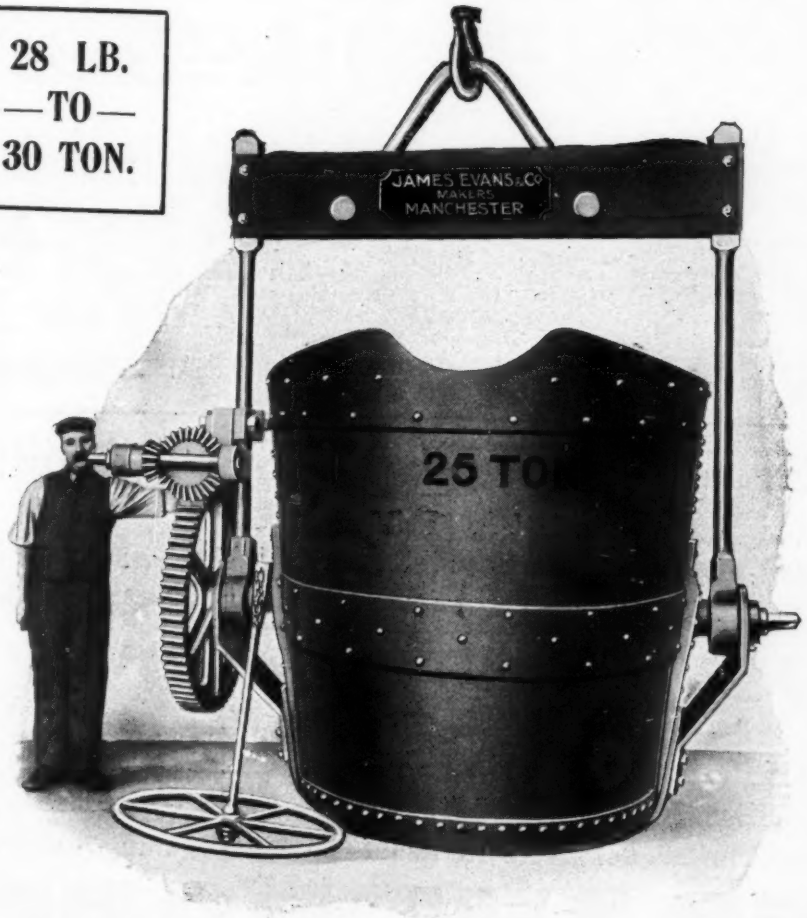
DAVIES, MIDDLETON & COMPANY, LIMITED.—Capital £9,000 in £1 shares, to acquire the business carried on by T. W. Davies, to adopt an agreement with T. W. Davies and H. Middleton, and to carry on the business of engineers, contractors, etc. Registered office: 24, Duke Street, Cardiff.

FRANCIS OWEN & COMPANY, LIMITED.—Capital £5,000 in £1 shares (1,000 6 per cent. par. pref.), to take over the business of brassfounders and general ironmongers carried on by F. E. Owen and E. Blackmore at 61-5, Warwick Road, Stratford, as F. E. Owen & Company. Registered office: 61, Warwick Road, Stratford.

SMITH & MOLESWORTH, LIMITED.—Capital £8,000 in £1 shares, to acquire the business carried on at Freeth Street, Coventry, as Smith & Molesworth, to adopt an agreement with G. S. Smith, J. Molesworth, G. E.

FOUNDRY LADLES.

28 LB.
—TO—
30 TON.



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SAMUEL WITHERS & COMPANY, LIMITED.—Capital £10,000 in £1 shares, to take over the business of a manufacturer of safes, springs, and ironfounders' goods, carried on by S. Withers at West Bromwich, as Samuel Withers & Company, and the Empire Spring Company. Registered office: Park Works, Barton Street, West Bromwich.

BAR METAL COMPANY, LIMITED.—Capital £5,000 in £1 shares, to acquire the purchasers' interest in an agreement between J. R. Bowick, A. J. Aitkens, F. H. Rogers, R. W. Conin, and S. C. Pratt, and to carry on the business of merchants, metal founders, etc. Registered office: Broad Sanctuary Chambers, Westminster.

F. W. WILLIAMS & COMPANY (STOKE-ON-TRENT), LIMITED.—Capital £3,000 in £1 shares, to take over the business of manufacturers and dealers in all kinds of goods used by potters, iron and steel manufacturers, colliery proprietors, engineers, etc., carried on by E. Rock and F. W. Williams at Wharf Street, Stoke-on-Trent, as F. W. Williams & Company. Registered office: Wharf Street, Stoke-on-Trent.

Deaths.

MR. C. DAY, ironfounder, of Puckeridge, died recently, aged 54 years.

MR. Y. H. MORLEY, ironfounder, Halifax, died recently, at the age of 66 years.

MR. S. KELSEY, an original director of Marshall, Sons & Company, Limited, Gainsborough, died recently, aged 74 years.

MR. J. BERTRAM, of J. Bertram & Sons, Limited, Leith Walk Foundry, Leith, died on February 20 last, aged 54 years.

MR. W. HILL, son of the late Mr. J. Hill, the founder of the firm of James Hill & Son, ironfounders, Bolton Street, Bury, Lancashire, died recently, aged 67 years.

MR. H. HUNT, a director of R. Hunt & Company, Limited, engineers and ironfounders, of the Atlas Works, Earls Colne, Halstead, and eldest son of Mr. R. Hunt, the founder of the firm, died recently, aged 41 years.

THE death occurred, on March 1, at his residence, Beech House, Somerset Road, Edgbaston, of Mr. Frederick Everitt, at the age of 72. Mr. Everitt was formerly a member of the firm of Allen Everitt & Sons, Smethwick.

MR. M. W. BUTTERS, senior partner of the firm of Butters Brothers & Company, cranemakers and engineers, Kinning Park, Glasgow, died last month. Mr. Butters was well-known in the building trade in Glasgow, and his firm specialised in the manufacture of Scotch derrick cranes.

THE death of Mr. H. G. Powell took place last month at the age of 64. In early life the deceased took a deep interest in the study of chemistry, and when he entered into the employment of Messrs. T. & C. Clark, the well-known cast-iron hollow-ware manufacturers, of Horseley Fields, Wolverhampton, he made a chemical discovery in the enamelling of iron ware which had a far-reaching effect. Mr. Powell was a member of the Iron and Steel Institute, a Fellow of the Royal Geographical Society, and a member of the British Association.

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FIRE CLAY.
Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.
STEEL MOULDERS' COMPOSITION, SILICA CEMENT.
J. GRAYSON LOWOOD & Co., Ltd.,
DEEPCAR, nr. SHEFFIELD.
Telegrams: "LOWOOD, DEEPCAR."

The Old English Firm for Superior Quality and Cheapest
STRAW ROPES
IS PROCTOR BOWES & Co., Newcastle-upon-Tyne.
Write for Prices Immediately.
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REG. TRADE MARK.

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REPAIR SHOP

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ELDERS FOUNDRY COKE

AS SUPPLIED TO THE BRITISH ADMIRALTY DOCKYARDS.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.
We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blowholes and other defects, than we formerly did.

From MOUNTFORD PHILLIPS & CO., Llantrissant.

Llantrissant, October 25th, 1904.

In reference to the Foundry Coke you have been supplying us with for the last six months, we have very great pleasure in letting you know that it has given every satisfaction, and that our Works Manager and Workmen give it the highest praise.

Elders Navigation Collieries, Ltd., Cardiff.

PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years :—

METALS.	End Mar., 1909.	End Mar., 1908.
Iron—Scotch pig warrants ton	52/4½	*56/9
—Middlesbro' warrants ... ton	46 4½	51 1½
—W.C. M/nos Bessemer ... ton	57 0	62 0
—Stock, Scotch ... ... tons	1,000	1,028
Copper—Chili bars, G.M.B. ton	£56 7 6	£59 5 0
—Stock, Europe and afloat tons	152,355	23,265
Tin—English ingots ... ton	£132 10 0	£142 10 0
—Straits ... ... ton	£130 17 6	£141 15 0
—Stock, London, Holland, U.S.A., and afloat ...tons	120,912	15,755
Lead—English pig ... ton	£14 0 0	£14 12 6
Spelter—Ord. Silesian ... ton	£21 8 9	£21 5 0
Quicksilver (75lb)... bottle	£8 7 6	£8 4 6
Antimony—Regulus ... ton	£30 0 0- £31 10 0	£34 0 0

* Settlement price. † Mid-monthly figures. ‡ End of Feb.

CASTINGS.

In the Cleveland district the following are the nominal rates current for castings :—

	£ s. d.		£ s. d.
Columns (plain)	6 15 0	to	7 0 0
Pipes, 1½ to 2½ in.	5 2 6	to	5 7 6
,, 3 to 4 in.	4 15 0	to	5 5 0
,, 5 to 8 in.	4 12 6	to	4 15 0
,, 10 to 16 in.	4 12 6	to	4 15 0
,, 18 to 24 in.	4 12 6	to	4 15 0
Chairs	3 10 0	to	3 12 6
Floor plates (open sand)	3 0 0	to	3 5 0

SCRAP.

The quotations for scrap, subject to market fluctuations, are as follows: —Heavy wrought (mixed), £2 8s. 0d.; light wrought, £1 1s. 0d.; heavy cast, £2 7s. 0d.; all per ton f.o.b., London. Copper (clean), £52 0s. 0d.; brass (clean), £39 0s. 0d.; lead (usual draft), £12 10s. 0d.; tea lead, £11 5s. 0d.; zinc, £17 5s. 0d.; all per ton delivered merchant's yard.

MACHINE SPUN
STRAW ROPES
of usual standard qualities are as popular as ever, and now much reduced in price.
WOOD CORE ROPES
of all sizes also always in stock.
WILLIAM OLSEN,
Cogan Street, HULL.

WILLIAM OLSEN,
Cogan Street, HULL,
Importer and Manufacturer of
PLUMBAGO & BLACKING
FOR ALL PURPOSES.
All Founders practising economy should write for samples and quotations for carriage paid deliveries.

SILICA FIRE BRICK Co.,
OUGHTIBRIDGE.
GROUND GANISTER,
WET OR DRY.
Silco Cupola Bricks, 90 % Silica.
Better than Fire-clay Bricks for Cupolas.

Established 1863.

JAS. DURRANS & SONS,

PHŒNIX WORKS, PENISTONE, Near Sheffield.

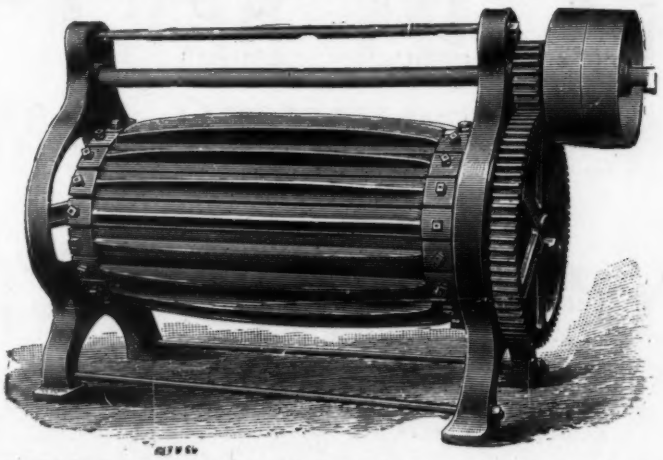
Manufacturers of all

FOUNDRY EQUIPMENTS,

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST.

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

IMPROVED FOUNDRY RATTLER or FETTLING DRUM.



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Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD."

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IT is used for filling up blowholes and sand holes in Cast Iron or Steel Castings.
IT is supplied in powder form and mixed for use with a little water to a stiff paste.
IT dries on a casting in 1 hour, and can be filed up bright in from 6 to 12 hours.
IT is specially useful to all Engineers, Machinists, Foundrymen, etc.
IT is of British Manufacture.

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THE BUYER'S GUIDE

Addresses and further information will be found by reference to the Firm's Advertisement.

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Jackman, J. W., & Co., Ltd.
Phillips, J. W. & C. J.
Thwaites Bros., Ltd.
Tilghman's Patent Sand Blast Co., Ltd.

Air Compressors (Electrically Driven).
Jackman, J. W., & Co., Ltd.
Tilghman's Patent Sand Blast Co., Ltd.

Air Compressors (Steam).
Jackman, J. W., & Co., Ltd.
Tilghman's Patent Sand Blast Co., Ltd.

Air Compressors (Belt).
Jackman, J. W., & Co., Ltd.
Tilghman's Patent Sand Blast Co., Ltd.

Annealing.
Phillips, J. W. & C. J.

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Phillips, J. W. & C. J.

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Jackman, J. W., & Co., Ltd.

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Walker, I. & I.

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Evans, J. & Co.
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Olsen, William.

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Phillips, J. W. & C. J.

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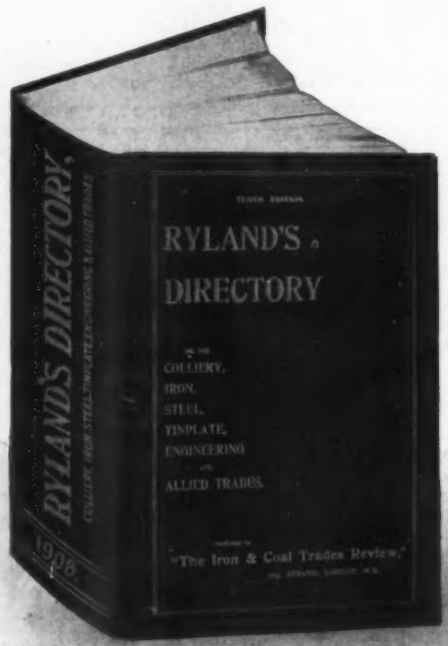
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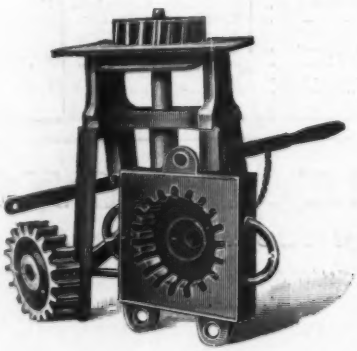

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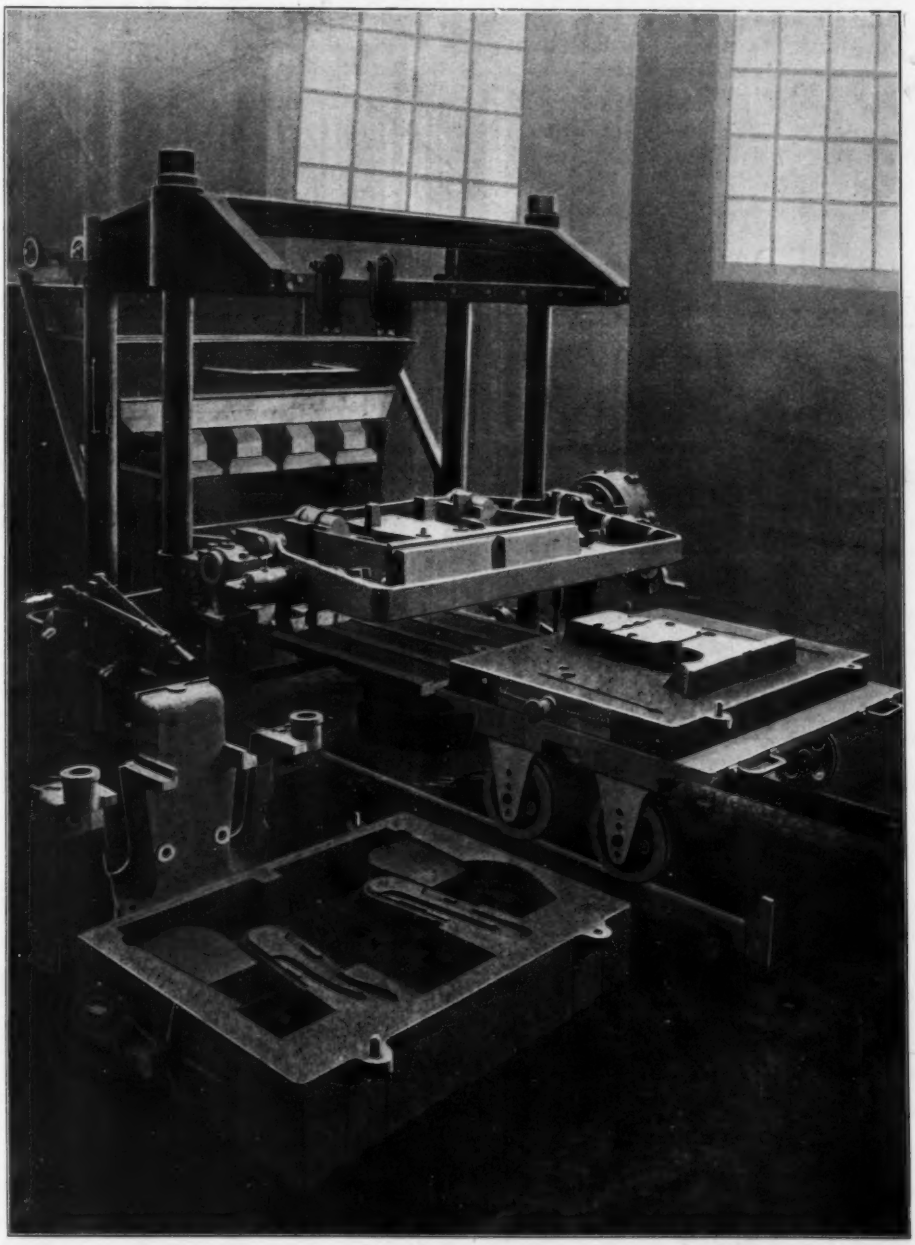

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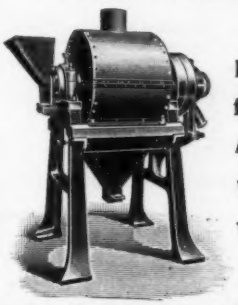

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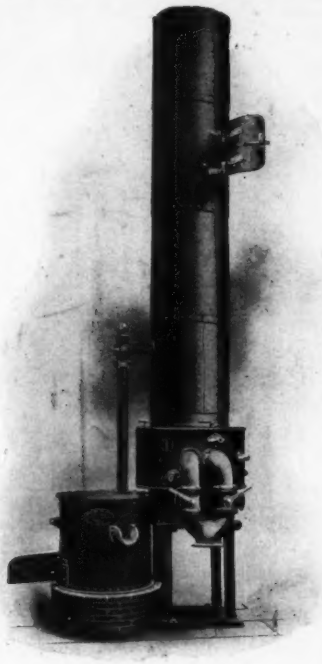

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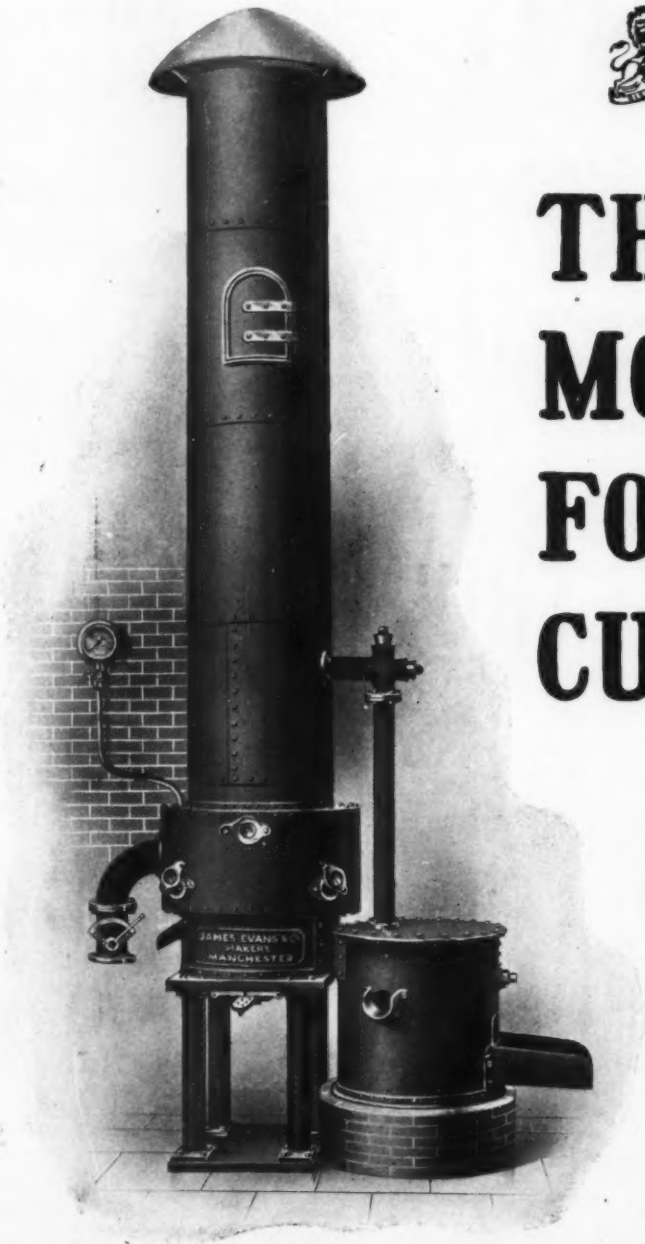

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